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A study of intensities of rainfall recorded at places in Scotland

by

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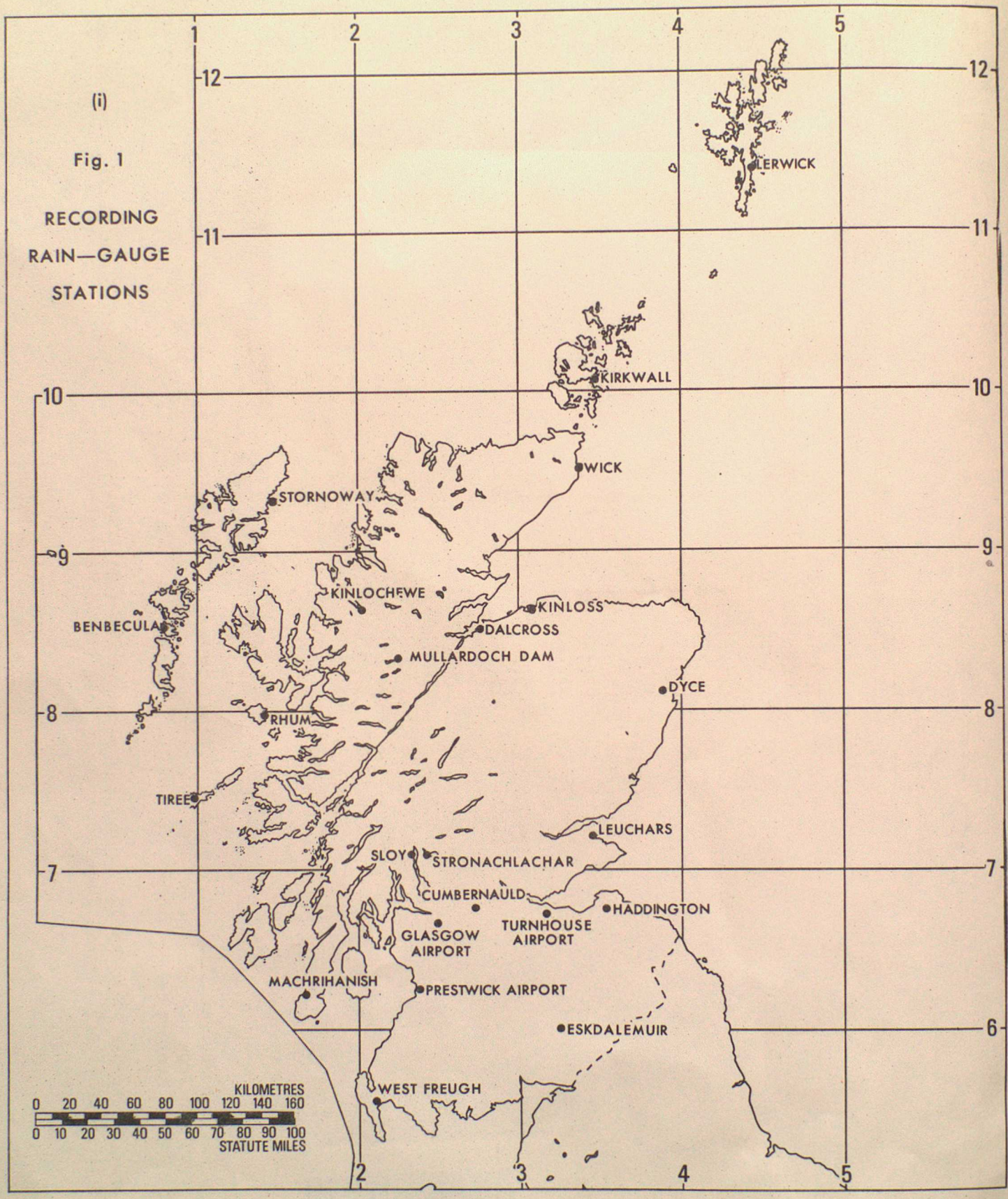
Fig. 1

RECORDING RAIN—GAUGE STATIONS



Details of recording raingauge stations

Station	Hydrological station number	National grid reference	Altitude (metres)	Period of record	Annual average rainfall 1916-50 (millimetres)	Table numbers	Page numbers of tables
Eskdalemuir, Dumfriesshire	63-610122	NT/36)235026	242	1938-70	1582	1, 1A	11-13
West Freugh, Wigtownshire	61-637507	NX(25)109546	15	1947-70	1015	2, 2A	14-15
Prestwick Airport, Ayrshire	72-645590	NS(26)369261	16	1947-70	938	3, 3A	16-17
Glasgow Airport, Renfrewshire†	73-660285	NS(26)480667	5	1938-70	1035	4, 4A	18-20
Sloy Power Station, Dunbartonshire	74-662041	NN(27)324099	12	1961-70	2699	5, 5A	21-22
Machrihanish, Argyll	77-675177	NR(16)663226	10	1965-70	1097	6, 6A	23-24
Kinlochewe, Ross & Cromarty	89-713571	NH(28)024630	23	1965-70	1970	7, 7A	25-26
Tiree, Inner Hebrides	77-719008	NL(07)999446	9	1954-70	1117	8, 8A	27-28
Isle of Rhum, Inner Hebrides	88-719395	NM(17)402996	5	1962-70	2520	9, 9A	29-30
Stornoway, Outer Hebrides	89-727288	NB(19)459332	3	1954-70	1002	10, 10A	31-32
Benbecula, Outer Hebrides	88-736633	NF(08)782555	5	1954-70	1140	11, 11A	33-34
Lerwick, Shetland	93-763886	HU(N41)453397	82	1954-70	1132	12, 12A	35-36
Kirkwall Airport, Orkney*	92-767475	HY(N30)483076	26	1947-70	1000	13, 13A	37-38
Wick, Caithness	91-770765	ND(39)364522	36	1948-70	761	14, 14A	39-40
Mullardoch Dam, Inverness-shire	88-795625	NH(28)223310	245	1963-70	1744	15, 15A	41-42
Dalcross (Inverness) Airport	88-805708	NH(28)766520	11	1961-70	652	16, 16A	43-44
Kinloss, Morayshire	86-811394	NJ(38)067627	5	1951-70	614	17, 17A	45-46
Dyce (Aberdeen) Airport	84-841490	NJ(38)883125	58	1946-70	895	18, 18A	47-48
Leuchars, Fife	80-885313	NO(37)468208	10	1937-70	678	19, 19A	49-51
Stronachlachar, Stirlingshire	75-891986	NN(27)401103	117	1959-70	2379	20, 20A	52-53
Cumbernauld, East Dunbartonshire	74-896452	NS(26)772760	94	1961-70	1147	21, 21A	54-55
Turnhouse (Edinburgh) Airport	69-899407	NT(36)159739	35	1949-70	685	22, 22A	56-57
Haddington, East Lothian	68-903308	NT(36)513736	49	1964-70	650	23, 23A	58-59

†The rainfall recorder at Glasgow Airport was sited at Glasgow (Abbotsinch) Airport during the period from January 1938 to October 1945 and from May 1966 to December 1970. It was sited at Glasgow (Renfrew) Airport during the period from November 1945 to April 1966.

*The rainfall recorder at Kirkwall Airport was sited at Kirkwall (Hatston) Airport during the years from 1947 to 1949 and at Kirkwall (Grimsetter) Airport during the years from 1950 to 1970.

A study of intensities of rainfall recorded at places in Scotland

by J A Plant

Introduction

A rational basis for the classification of heavy falls of rain in short periods of time ranging from a few minutes to a number of hours was first developed for the United Kingdom in an article by E G Bilham in the 1935 volume of 'British Rainfall'[(1)]. The current position with regard to the frequency analysis of intense falls of this type is discussed in an article by D J Holland in the 1961 volume of 'British Rainfall'[(2)].

For practical applications, which are very often related to the design of storm-water sewerage systems, the most useful basic data on intense falls of rain have been obtained from the systematic analysis of information provided by recording raingauges of the autographic type.

There are very few stations in Scotland equipped with autographic recording raingauges and one of the main aims of this study is to collect together the maximum amount of information concerning frequencies of falls within stated categories recorded by the 23 Scottish stations which at the end of 1970 had complete records over 6 continuous years or more. Details of the 23 stations including the period of records available and the annual average rainfall are given on the opposite page. A map showing the locations of the 23 stations is at Fig 1.

Frequencies of intense falls of rain in short periods of time for a small selection of stations in the United Kingdom have been published in the annual volumes of 'British Rainfall' (Table 6A in the volume for 1961 and Table 6D in previous volumes) for a long period of years and when summarizing the data for the 23 stations in Tables 1 to 23 it was found convenient to use criteria and methods of tabulation similar to those used in 'British Rainfall'.

When studying Tables 1 to 23 it should be noted that the falls are not necessarily continuous nor are they always confined to one particular day. Not more than one fall of each specified amount is credited to any day; if more than the specified amount fell on any day, that part of it which fell in the shortest time is used for the Table. An entry of 5 mm (0.2 inch) falling within 5 minutes or less, naturally recurs in the next two columns viz 10 minutes or less and 15 minutes or less and there is a similar recurrence of the entries under the headings 10 mm (0.4 inch), 15 mm (0.6 inch), 20 mm (0.8 inch) and 25 mm (1.0 inch).

Records of amounts of 5 mm (0.2 inch) falling within 5 minutes, 10 minutes and 15 minutes are not available for the years before 1956.

The total number of days with rain falling in each of the stated categories together with the number of years of available records are shown at the foot of each Table and using these two values, an observed frequency of the number of days in 10 years with specified amounts of rain falling in specified times has been calculated for each of the 23 stations in Table 24.

A special mention should be made of the very rare intensities of rainfall recorded during a downpour at Eskdalemuir near Moffat in Dumfriesshire on 26 June 1953. During this downpour 3.15 inches was recorded in 30 minutes, the heaviest known fall of that duration in the United Kingdom. During the same downpour, 3.54 inches was recorded in 55 minutes (ie a rate per hour of 3.86 inches) which is also a United Kingdom record for 55 minutes. A more recent downpour which also deserves a special mention occurred at Lossiemouth in Morayshire on 7 June 1970. The station at Lossiemouth is not equipped with a recording raingauge but during the afternoon of 7 June 1970, 2.19 inches was collected in a standard raingauge within 1 hour and 3.65 inches was collected within 2 hours.

Discussion of the data contained in Tables 1 to 24

It is clear from Tables 1 to 24 that the more intense the rainfall, the less likely it is to last for a given period of minutes or hours. It is also clear that the incidence of heavy rains in short periods is very fortuitous. For example, the falls of 0.6 inches in 15 minutes or less and 0.8 inches within 30 minutes at Dyce (Aberdeen) Airport in Table 18 were both recorded during two unusually intense downpours on 18 June 1946 and 1 August 1948 and it is interesting to note that similar falls did not occur again at the Airport during the following 22 year period ending in 1970.

The reader will notice from Table 24 that places with a high annual average rainfall like Eskdalemuir and Stronachlachar are much more liable to prolonged heavy rains than places with a relatively low annual average rainfall like Kinloss and Leuchars. This point is discussed more fully at the end of this paper. On the other hand, it should also be noted that because a particular place has a relatively high annual average rainfall, it does not necessarily follow that it will also have a higher incidence of the really intense falls lasting no more than one hour or two. For example, Leuchars has an annual average rainfall of 678 mm while Stornoway has an annual average of 1002 mm and yet the incidence of intense falls with durations of 2 hours or less is much higher at Leuchars than it is at Stornoway.

At this point, it is important to bear in mind that in Scotland, as elsewhere in the British Isles, intense falls of rain with durations of about 2 hours or less are nearly always associated with thunderstorms or thundery activity. Thus, if records of rainfall intensities for a particular location do not exist, the frequency of thunderstorms at that location, and not the annual average rainfall, serves as the best available indication of the incidence of the really intense falls of short duration.

General experience appears to confirm the theoretical expectation that the hills in Scotland often provide the extra uplift of the air required to set off or intensify thundery activity. For example, it will be seen from Table 24 that a place in hilly terrain like Eskdalemuir is much more prone to intense falls of 2 hours duration or less than a place in relatively flat, low-lying terrain like West Freugh. Similarly, the incidence of the really intense falls of short duration is much higher on a

mountainous island like Rhum than on the flat, low-lying island of Tiree which lie reasonably near to each other in the Inner Hebrides.

The frequency of thunderstorms and thundery downpours at the main centres of population in Scotland is relatively low but the hills are not very far away from Scottish cities and there is little doubt that the frequency of thundery activity over the Pentland Hills and Lammermuirs just to the south and southeast of Edinburgh is higher than in Edinburgh itself. Similarly, experience suggests that the Renfrewshire Hills, Kilsyth Hills and Ochils have a higher frequency of thundery downpours than Glasgow and other centres of population in the Clyde/Forth valley. Indeed, it could be said that cities like Edinburgh, Glasgow, Aberdeen and Dundee which all lie on relatively low ground near hills are subject to a number of near misses as far as the really intense falls of short duration are concerned.

Having noted that the incidence of intense falls of rain with durations of about 2 hours or less is greater over the upland parts of Scotland, particularly over the upland parts of central and southwest Scotland, than over the lower lying parts of the country, further study of the figures in Tables 1 to 24 reveals that the variation from place to place in the incidence of intense falls of short duration is by no means clear-cut and the enormous gaps in the network of recording stations and the short period nature of most of the available records certainly does not help to throw light on the problem. For practical applications, this is most unfortunate, because nearly all the requests for advice about intensities of rainfall received by the Meteorological Office from engineers in Scotland are concerned with the frequency of these intense falls of rain with durations of less than 2 hours.

Comparison of the observed frequencies in Table 24 with frequencies estimated from the Bilham formula

In view of the sparseness of the network of recording raingauges in the United Kingdom and the short-period nature of most of the available records, drainage engineers make wide use of intensities of rainfall estimated from the Bilham formula:-

$$n = \frac{1.25\ t}{(r + 0.1)^{3.55}}$$

where n = frequency (number of days in 10 years)

t = duration in hours

r = rainfall in inches

For example, rates of rainfall given by the Bilham formula for a range of durations and frequencies are included in Road Note No. 35 of the Road Research Laboratory published by HM Stationery Office in 1963 (reprinted 1967) under the title of 'A guide for engineers to the design of storm sewer systems'.

Bilham's formula dates from his article in the 1935 volume of 'British Rainfall'[(1)]. Nevertheless, it has stood the test of time remarkably well and although the formula was obtained from intensities of rainfall recorded at 12 stations in England and Wales (one station in Anglesey and the rest in various parts of England

including 3 stations in the London area) it has also been widely used to estimate intensities of rainfall at places in Scotland.

The period of observed rainfall intensities available from most Scottish rain recorder stations is too short, in some cases much too short, to obtain a reliable indication of the long term relationship between intensity and frequency at any individual station. Nevertheless, the observed frequencies at individual stations in Tables 1 to 23 when considered together (see Table 24) do permit some useful conclusions to be made. However, even a brief perusal of Table 24 will reveal the complexity of the frequencies and the difficulty in making conclusions from the figures as they stand.

There is a rather obvious need for some kind of standard against which the observed frequencies in Table 24 can all be assessed. In the case of the really intense falls with durations of 2 hours or less, the only satisfactory yardstick available at the present time is a frequency estimated from the Bilham formula. Bilham was well aware of the shortcomings of his formula for estimating falls with durations in excess of 2 hours and did not consider that an extension of his working curves beyond 2 hours is desirable[1]. Nevertheless, for the purposes of this study and in the absence of a satisfactory alternative measure, it was decided to compare the frequency of all the observed falls, irrespective of duration, with frequencies obtained from the Bilham formula. Accordingly, the observed frequencies for the 23 stations in Table 24 are compared with frequencies obtained from the Bilham formula in Tables 1A to 23A. Following a recent investigation by D J Holland[2][3] it has become necessary to modify the frequencies obtained from Bilham's formula in respect of intensities greater than 1.25 inches per hour and the intensities marked with an asterisk in Tables 1A to 23A have been obtained from the formula given in Note 2 at the foot of each Table.

It will be noticed from Tables 1A to 23A that, in some cases, the observed frequency of the number of days in 10 years with specified amounts of rain falling in specified times has been calculated from less than 10 years of recordings. Thus, the "observed" frequencies for places with short term records viz Mullardoch Dam, Haddington, Kinlochewe, Isle of Rhum and Machrihanish have been partially estimated and must be treated with some reserve. In general, records covering a number of decades are desirable before attempting to estimate the average frequency over a 10 year period. Nevertheless, in view of the general dearth of records of rainfall intensities from places in Scotland, particularly in the areas in which the short term stations are situated, it is considered that, taken together, the shorter term records may give some indication of any regional variations. These records have therefore been included for what they are worth.

Column C of Tables 1A to 23A gives for each station, the observed frequency estimated as a percentage of the estimated Bilham frequency. For ease of comparison, the values in Column C of Tables 1A to 23A are summarized in Table 24A.

Discussion of the data contained in Tables 1A to 24A

It is clear from the comparisons provided in Tables 1A to 24A that at all stations there are wide departures from the frequencies estimated from Bilham's formula. There is no doubt that in many cases the departures from the Bilham frequencies are partly due to the short-period nature of the records used to calculate the observed frequencies. The reader should also realise that because of the infrequency and fortuitous incidence of the really intense falls of short duration, differences between the observed and estimated frequencies are inevitable. For example, mention has already been made of two intense falls of rain which occurred at Dyce (Aberdeen) Airport in June 1946 and August 1948 and it can be seen from Table 18A that it is these two falls which account for the two values in Column C which are considerably out of keeping with the other values viz 89% for 0.6 inches in 15 minutes or less and 100% for 0.8 inches in 30 minutes or less. The observed frequencies in Table 18A have been calculated from 25 years of recordings and it is considered that to have two falls of this magnitude and duration in the Aberdeen area during a period as short as 25 years is something of an accident.

The example quoted in the previous paragraph serves to re-emphasise the need for caution when dealing with short-term records. Nevertheless, there are sound physical reasons for thinking that the general tendencies shown by the Tables are real.

As mentioned previously, the very intense falls lasting no more than one hour or two are associated with thunderstorms or thundery activity and Bilham based his formula mainly on recordings made at stations in England. When compared with the main centres of population in Scotland, parts of central and southern England have two to three times as many thunderstorms and thus it could perhaps be expected that with the possible exception of places in the upland parts of Scotland where the higher frequency of thunderstorms has already been noted, the frequency of intense falls of rain with durations of about two hours or less would be less in Scotland than in England.

The reader will notice from Table 24A that in general, the observed frequency of these thundery downpours of short duration is less at Scottish stations, in some cases considerably less, than the estimated frequencies obtained from the Bilham formula - notable exceptions being Eskdalemuir, Sloy and Stronachlachar (Tables 1A, 5A and 20A) which all lie in hilly terrain. It is unfortunate that the period of records available from the remaining mainland hill station at Mullardoch Dam (Table 15A) is so short because it is thought that a longer period of records might give an observed frequency more similar to that at the other hill stations although the recorded frequency of falls of 10 millimetres in 1 hour or less at Mullardoch Dam is in excess of the frequency obtained from the Bilham formula.

One other station which could be classified as a mainland hill station is Kinlochewe (Table 7A) at the south eastern end of Loch Maree in Wester Ross. Although Kinlochewe lies on low ground, the neighbouring high ground rises to over 3,000 feet and in common with the station at Mullardoch Dam, it is thought that the surprisingly

low frequency of intense falls of 2 hours or less at Kinlochewe may be due to the fact that only 6 years of recordings are available from this station.

Tables 8A to 13A give a comparison of the frequencies recorded at 6 stations in Shetland, Orkney and the Western Isles. With the exception of Rhum, the only mountainous island, the remaining 5 island stations show an observed frequency of falls with durations up to 2 hours which is low when compared with the frequencies estimated from the Bilham formula.

Apart from Haddington (Table 23A), the east coast stations at Wick, Dalcross, Kinloss, Dyce, Leuchars and Turnhouse (Tables 14A, 16A, 17A, 18A, 19A and 22A) also show an observed frequency of falls with durations of 2 hours or less which is low when compared with the Bilham frequencies. The fortuitous incidence of heavy falls of short duration has already been mentioned including an example which emphasised the effect of two unusually intense downpours at Dyce on the observed frequencies calculated for the Aberdeen station. A similar intense downpour occurred at Haddington on 15 August 1967 when 5 mm fell in 6 minutes, 10 mm in 12 minutes, 15 mm in 18 minutes, 20 mm in 24 minutes and 25 mm in 30 minutes and it will be noticed from Column C of Table 23A that this single downpour has resulted in frequencies which are out of keeping with the other frequencies. The Haddington record is much too short to draw any definite conclusions from this. It would be surprising if Haddington differed greatly from the other east coast stations. On the other hand the proximity of the Lammermuirs may mean that the near misses do not always miss.

It is unfortunate that records of rainfall intensities from Cumbernauld are only available for the 10 years between 1961 and 1970 as this station is the only station in the central part of the Clyde/Forth valley between Glasgow and Edinburgh. Nevertheless, the frequencies in Table 21A do serve to indicate that Cumbernauld also has a low frequency of the really intense falls of short duration.

The west coast stations at West Freugh near Stranraer, Prestwick Airport, Glasgow Airport and Machrihanish near Campbeltown also show (Tables 2A, 3A, 4A and 6A) a low frequency of intense falls with durations of 2 hours or less, although the observed frequency of falls of 15 mm in 2 hours or less at West Freugh is very similar to the frequency estimated from the Bilham formula.

Conclusions

The frequency comparisons in Tables 1A to 24A suggest that except in the hilly parts of the Scottish mainland and Western Isles, the frequencies of intense rainfalls with durations of about 2 hours or less are generally much lower than those obtained from the Bilham formula.

Clearly, until the enormous gaps in the network of rain recorder stations in Scotland are filled and many more long period records of rainfall intensities become available, it will not be possible to make an entirely reliable and objective assessment of the regional variations in the frequency of falls of this type which obviously exist. However, the evidence available at the present time coupled with general

meteorological experience suggests that for practical applications, the frequencies obtained from the Bilham formula in respect of intense falls with durations of 2 hours or less could be halved when applied to the areas, cities and towns listed below ie a return period of 10 years obtained from the Bilham frequencies would become 20 years when applied to the locations listed below. Alternatively, for intense falls of rain with durations of 2 hours or less, a 20 per cent reduction could be made to the amounts obtained from Bilham's formula when considering sewerage or drainage design etc at the locations listed below.

1. Northern Isles

   All locations in Orkney and Shetland.

2. North Coast of Scotland

   All locations on the north coast of Scotland including Durness, Tongue, Bettyhill, Dounreay and Thurso.

3. East Coast of Scotland

   All locations on the east coast of Scotland including Wick, Invergordon, (Dingwall), Inverness, Nairn, Elgin, Banff, Fraserburgh, Aberdeen, Stonehaven, Montrose, Arbroath, Dundee, (Perth), St Andrews, Cupar, Leven, (Glenrothes), Kirkcaldy, Dunfermline, Grangemouth, Edinburgh, (Haddington), North Berwick and (Dunbar).

4. Western Isles

   Isle of Lewis, North Uist, South Uist, Col, Tiree and Colonsay.

5. Mull of Kintyre

   All locations on the western coastal strip of Mull of Kintyre.

6. Central Belt of Scotland

   Paisley, Glasgow, Hamilton, Motherwell, Airdrie, Coatbridge, Kirkintilloch, Cumbernauld, (Stirling), Falkirk, Linlithgow and (Bathgate).

7. Ayrshire

   Irvine, (Kilmarnock), Prestwick, Ayr and (Girvan).

8. Wigtownshire

   (Stranraer).

The locations in paragraphs 1 to 8 above which are enclosed in brackets, lie near to hilly terrain and are probably border-line cases as far as reductions to the Bilham frequencies are concerned. For example, although the suggested reduction would be in order for the Burgh of Kilmarnock, a similar reduction could not be recommended for locations in or near to the hills immediately to the north and east of Kilmarnock in view of the higher frequency of thunderstorms and thundery downpours over these hills.

In the Southern Uplands and along the narrow coastal strip of the southwestern counties adjacent to the Solway Firth, the network of climatological stations with long term records of the frequency of thunderstorms is very scant. Nevertheless, the available evidence suggests that the Southern Uplands and perhaps the centres of population

on or near to the Solway coastline have a relatively high incidence of thundery activity when compared with other regions of Scotland. For this reason, reductions to the Bilham frequencies cannot be recommended for the centres of population on or near to the Solway coast including Wigtown, Newton Stewart, Gatehouse of Fleet, Kirkcudbright, Castle Douglas, Dalbeattie, Dumfries and Annan.

Similarly, until much more evidence becomes available, reductions to the Bilham frequencies cannot be recommended for the Fort William, Oban and Greenock areas, for the upland parts of Scotland and for all other locations and regions not included in paragraphs 1 to 8 above.

Frequencies of maximum amounts of rainfall calculated from the Bilham formula

For ease of reference, frequencies of maximum amounts of rainfall in inches calculated from the Bilham formula (modified by D J Holland in respect of intensities greater than 1.25 inches per hour[3]) are given in the upper table of Table 25 for durations ranging from 2 minutes to 2 hours.

Factors for converting point rainfall into areal rainfall

So far, all the data discussed in this paper refer to rainfall at a point (ie rain falling over the area of the aperture of the recording raingauge which has a diameter of 11.31 inches) but areal rainfall is required for most design purposes. Because of the variability of intense falls of rain in space and time, the areal rainfall for a given duration and return period is, in general, smaller than the corresponding point rainfall. To obtain areal rainfall, the point rainfall should be multiplied by the appropriate factor in the lower table of Table 25. These factors were derived from a formula by D J Holland, assuming a roughly circular area and a roughly equal contribution to the drainage system from all parts of the area[4].

Frequencies of rainfalls with durations of 4 to 8 hours or more

As mentioned earlier in this paper, nearly all requests for advice about intensities of rainfall received by the Meteorological Office from engineers in Scotland are concerned with the frequency of intense falls of rain with durations of 2 hours or less and this is the reason why special attention has been paid in this study to falls of this type. However, in some cases, it may be equally important to note from Tables 1A to 24A that for falls with durations of 4 to 8 hours or more, the estimated frequencies obtained from the Bilham formula are considerably lower than the observed frequencies at many of the recording stations. In general, the longer the period of the fall, the greater is the increase in the observed frequency above the estimated Bilham frequency. For example, it can be seen from Table 24A that the observed frequency of falls of 1 inch in 4 hours or less at Stronachlachar is more than 4 times greater than the frequency estimated from the Bilham formula and more than 10 times greater in the case of falls of 1 inch in 16 hours or less.

It is possible to detect from the figures in Table 24A, some indications of a link between annual average rainfall and the more prolonged falls with durations of 4 to 8 hours or more. To facilitate further study of a possible link of this kind, the

percentages of falls of 25 mm within 16 hours, 20 mm within 8 hours and 15 mm within 4 hours given in Table 24A are re-presented in Table 26 but with the stations ranked according to annual average rainfall.

Discussion of the data contained in Table 26

A study of the three classes of falls presented in Table 26 produces useful results:

25 mm in 16 hours

For the first 9 stations in order of annual average rainfall, the percentages in Table 26 are also in order except for Eskdalemuir - Mullardoch Dam. Because of the very short period of records available from Mullardoch Dam, mention of which has been made earlier in this paper, it is considered that Mullardoch Dam and not Eskdalemuir is the station out of step.

The four west coast stations (labelled W in Table 26) at Tiree, Machrihanish, Glasgow Airport and West Freugh also form a coherent group although the remaining west coast station at Prestwick Airport is out of step.

The four east coast stations (labelled E in Table 26) at Turnhouse, Leuchars, Dalcross and Haddington can be grouped together in a similar way but with Dyce out of step.

The three northerly stations (labelled N in Table 26) at Stornoway, Kirkwall and Wick also form a group with Kinloss as a possible addition. The differences between Kinloss and the nearby station at Dalcross are not understood but may be due to the shorter period of records available from Dalcross. Lerwick could also be added to the Northern group with its higher annual average rainfall coming into play.

Thus, out of the total of 23 stations for which records are available, at most four (perhaps only two - Prestwick and Dyce) fail to fit a pattern based on annual average rainfall plus geographical grouping. This is a surprisingly good result bearing in mind the complexity of the terrain in Scotland.

20 mm in 8 hours

A result almost identical to the "25 mm in 16 hours" result.

15 mm in 4 hours

With the shortening time interval slightly more irregularities begin to appear eg Sloy - Rhum in addition to Eskdalemuir - Mullardoch; West Freugh and Dalcross are slightly more out of line and Dalcross and Kinloss seem to have changed places in the possible North and East groupings.

It is clear from the figures in Table 24A and Table 26 that somewhere around a duration threshold of 3 to 4 hours there is a discontinuity or transition zone. Broadly speaking, the reason for this discontinuity is that two quite different types of phenomena are involved - on the one hand thundery rains of up to something like 2 hours duration which affect a limited area and on the other hand prolonged heavy rain over a wide area due to a major weather feature such as a wave on a front or a slow moving depression. While there is an obvious link between annual average rainfall and

the frequency of falls with durations of 4 to 8 hours or more, the relationship is complicated by the fact that the records of these more prolonged falls are contaminated by the thundery type of fall when, for example, thunderstorms are imbedded in a major weather feature or perhaps two or more thunderstorms occur separated by a number of hours. It is possible that the records of falls with durations of 4 to 8 hours or more for Prestwick and Dyce are particularly affected in this way and this may be the reason why the figures for Prestwick and Dyce do not fit into the respective west coast and east coast groupings.

Until more data relevant to this difficult problem are available, Table 26 serves to emphasise Bilham's own warning about extending the use of his formula beyond a time interval of a few hours.

References

1. E G Bilham - "Classification of heavy falls of rain in short periods" - British Rainfall 1935*
2. D J Holland - "Rain intensity/frequency relationships in Britain" - British Rainfall 1961†
3. D J Holland - "Tables of rainfall amounts and intensities for given durations and return periods together with area factor graphs" - Appendix to Hydrological Memorandum No. 33 - August 1968
4. D J Holland - "The Cardington Rainfall Experiment" - Meteorological Magazine Vol 96 - July 1967

*This article from the 1935 volume of 'British Rainfall' was published afresh in 1962 and is accordingly still available from HMSO.

†This article from the 1961 volume of 'British Rainfall' was also published separately in 1964 as Hydrological Memorandum No. 33 and is obtainable from the Meteorological Office.

Acknowledgements

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TABLE 1

Intensities of rainfall recorded at Eskdalemuir, Dumfriesshire

Number of days with specified amounts of rain falling in specified times (33 years from 1938 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	0	0	0	0	1	0	0	0	2	8	0	0	0	4	6	0	0	0	4	7
1969	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	1	4
1968	0	3	3	0	0	1	3	0	0	0	2	10	0	0	0	3	6	0	0	0	2	10
1967	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	2	11	0	0	1	6	13
1966	0	0	3	0	0	0	1	0	0	0	2	7	0	0	0	2	7	0	0	1	2	10
1965	0	1	1	0	0	1	1	0	0	0	1	2	0	0	1	1	5	0	0	1	2	6
1964	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	1	7	0	0	0	4	5
1963	0	0	1	0	0	0	1	0	0	0	0	7	0	0	0	0	9	0	0	0	4	8
1962	0	0	2	0	0	0	2	0	0	0	2	8	0	0	0	3	12	0	0	3	5	14
1961	2	2	2	0	0	0	0	0	0	0	0	4	0	0	0	1	6	0	0	0	4	6
1960	0	0	1	0	0	1	1	0	0	1	1	4	0	0	1	2	6	0	0	1	4	8
1959	1	1	3	0	1	2	3	0	0	2	2	10	0	0	1	2	10	0	0	0	2	7
1958	1	3	4	0	1	3	4	0	0	2	4	10	0	0	0	5	8	0	1	2	6	7
1957	0	1	1	0	1	1	2	0	0	0	1	6	0	0	0	3	7	0	0	0	2	5
1956	0	1	5	0	0	0	2	0	0	1	2	6	0	0	0	2	6	0	0	2	3	8
1955	-	-	-	0	0	0	0	0	0	0	0	4	0	0	0	0	4	0	0	0	3	6
1954	-	-	-	0	0	0	3	0	0	0	0	15	0	0	0	2	15	0	0	1	8	15
1953	-	-	-	1	1	2	2	1	1	1	2	7	1	1	2	2	6	1	1	2	3	9
1952	-	-	-	0	0	0	1	0	0	0	1	6	0	0	0	3	8	0	0	0	3	6
1951	-	-	-	0	0	0	1	0	0	0	0	5	0	0	0	0	9	0	0	0	2	10
1950	-	-	-	0	0	0	4	0	0	0	2	8	0	0	1	1	9	0	0	1	4	10
1949	-	-	-	0	1	1	2	0	1	1	3	8	0	0	1	3	9	0	0	2	6	8
1948	-	-	-	0	0	0	4	0	0	0	3	10	0	0	0	3	11	0	0	2	8	13
1947	-	-	-	0	1	1	1	0	0	0	0	7	0	0	0	0	5	0	0	0	3	7
1946	-	-	-	0	0	0	0	0	0	0	0	6	0	0	0	2	9	0	0	0	4	9

Contd overleaf

TABLE 1 (Contd)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1945	-	-	-	0	0	0	1	0	0	0	1	4	0	0	0	2	7	0	0	0	1	7
1944	-	-	-	0	0	0	2	0	0	0	1	9	0	0	0	3	8	0	0	1	6	9
1943	-	-	-	0	0	1	3	0	0	1	2	10	0	0	0	2	11	0	0	0	1	7
1942	-	-	-	0	0	2	2	0	0	0	2	4	0	0	1	1	3	0	0	1	2	4
1941	-	-	-	0	1	3	4	1	1	3	3	4	0	0	1	3	4	0	0	2	3	6
1940	-	-	-	0	0	0	0	0	0	0	2	8	0	0	0	5	8	0	0	1	3	11
1939	-	-	-	0	0	0	0	0	0	0	1	5	0	0	0	2	6	0	0	0	4	10
1938	-	-	-	0	1	1	1	0	0	0	2	17	0	0	0	4	17	0	0	0	8	15
Total	4	12	26	1	8	20	52	2	3	12	44	235	1	1	9	69	258	1	2	24	123	280
Number of Years of Record	15	15	15	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33

TABLE 1A

Comparison of observed and estimated intensities of rainfall at Eskdalemuir, Dumfriesshire

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed frequency (number of days in 10 years)	B. Estimated frequency (number of days in 10 years)	C. Observed frequency as percentage of estimated frequency	D. Period of record used for calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	2.7	5.5*	49%	15
10 minutes or less	8.0	14.9	54%	15
15 minutes or less	17.3	22.3	78%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.3	0.3*	100%	33
15 minutes or less	2.4	3.5*	69%	33
30 minutes or less	6.1	7.3	84%	33
60 minutes or less	15.8	14.6	108%	33
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.6	0.9*	67%	33
30 minutes or less	0.9	2.2	41%	33
1 hour or less	3.6	4.4	82%	33
2 hours or less	13.3	8.8	151%	33
4 hours or less	71.2	17.6	405%	33
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.3	0.8*	37%	33
1 hour or less	0.3	1.8	17%	33
2 hours or less	2.7	3.6	75%	33
4 hours or less	20.9	7.2	290%	33
8 hours or less	78.2	14.4	543%	33
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.3	0.9	33%	33
2 hours or less	0.6	1.8	33%	33
4 hours or less	7.3	3.6	203%	33
8 hours or less	37.3	7.2	518%	33
16 hours or less	84.8	14.4	589%	33

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Eskdalemuir during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 2

INTENSITIES OF RAINFALL RECORDED AT WEST FREUGH, NEAR STRANRAER, WIGTOWNSHIRE

Number of Days with Specified Amounts of Rain Falling in Specified Times (24 years from 1947 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	0	0	0	0	1	0	0	1	1	6	0	0	0	2	4	0	0	0	2	3
1969	0	0	1	0	0	0	1	0	0	0	1	2	0	0	0	2	2	0	0	0	2	3
1968	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1	3	0	0	0	2	5
1967	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	1	1
1966	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	1	0	0	0	1	3
1965	0	0	0	0	0	0	1	0	0	0	2	3	0	0	0	3	4	0	0	0	2	2
1964	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0	0	0	1	2
1963	0	1	1	0	0	0	0	0	0	0	0	3	0	0	0	1	2	0	0	0	1	2
1962	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0
1961	0	0	0	0	0	0	3	0	0	0	3	4	0	0	0	2	3	0	0	0	3	4
1960	0	1	1	0	0	0	0	0	0	0	1	7	0	0	0	3	6	0	0	0	5	6
1959	0	1	2	0	0	2	3	0	0	1	4	4	0	0	1	4	5	0	0	2	2	3
1958	0	0	0	0	0	0	1	0	0	0	0	4	0	0	0	1	2	0	0	0	1	3
1957	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	4	0	0	0	0	3
1956	0	2	2	0	1	2	3	0	0	1	1	5	0	0	0	0	1	0	0	0	0	0
1955	-	-	-	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	2
1954	-	-	-	0	0	1	1	0	0	0	0	8	0	0	0	1	7	0	0	0	2	6
1953	-	-	-	0	1	2	3	0	0	1	2	4	0	0	2	2	4	0	0	0	2	6
1952	-	-	-	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1
1951	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	2
1950	-	-	-	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	1	1
1949	-	-	-	0	0	0	1	0	0	0	1	3	0	0	1	1	4	0	0	1	2	3
1948	-	-	-	0	0	0	1	0	0	1	1	4	0	0	0	2	3	0	0	0	1	1
1947	-	-	-	0	0	1	1	0	0	1	2	2	0	0	0	0	1	0	0	0	1	3
Total	0	5	7	0	2	8	21	0	0	6	19	83	0	0	4	26	66	0	0	3	33	65
Number of Years of Record	15	15	15	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24

TABLE 2A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT WEST FREUGH, NEAR STRANRAER, WIGTOWNSHIRE

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.0	5.5*	0%	15
10 minutes or less	3.3	14.9	22%	15
15 minutes or less	4.7	22.3	21%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	24
15 minutes or less	0.8	3.5*	23%	24
30 minutes or less	3.3	7.3	45%	24
60 minutes or less	8.7	14.6	59%	24
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	24
30 minutes or less	0.0	2.2	0%	24
1 hour or less	2.5	4.4	57%	24
2 hours or less	7.9	8.8	90%	24
4 hours or less	34.6	17.6	197%	24
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	24
1 hour or less	0.0	1.8	0%	24
2 hours or less	1.7	3.6	47%	24
4 hours or less	10.8	7.2	150%	24
8 hours or less	27.5	14.4	191%	24
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	24
2 hours or less	0.0	1.8	0%	24
4 hours or less	1.3	3.6	36%	24
8 hours or less	13.7	7.2	190%	24
16 hours or less	27.1	14.4	188%	24

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at West Freugh during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 3

INTENSITIES OF RAINFALL RECORDED AT PRESTWICK AIRPORT, AYRSHIRE

Number of Days with Specified Amounts of Rain Falling in Specified Times (24 years from 1947 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	1	2	0	1	1	1	0	0	1	1	3	0	1	1	2	3	0	1	1	2	2
1969	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
1968	0	1	1	0	0	0	1	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1
1967	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1966	0	1	2	0	1	1	2	0	1	1	2	4	0	0	1	1	2	0	0	1	1	2
1965	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	1	0	0	0	0	1
1964	0	1	1	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0	0	0	1
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
1962	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	3	0	0	0	1	4
1961	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	1	4	0	0	1	1	3
1960	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	1	4
1959	0	0	2	0	0	0	1	0	0	0	1	2	0	0	0	0	0	0	0	0	0	2
1958	0	1	1	0	0	1	2	0	0	0	2	3	0	0	0	2	3	0	0	0	0	1
1957	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1
1955	-	-	-	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
1954	-	-	-	0	0	0	1	0	0	0	0	3	0	0	0	0	2	0	0	0	1	1
1953	-	-	-	0	0	0	2	0	0	0	0	1	0	0	0	0	2	0	0	0	0	1
1952	-	-	-	0	1	1	1	0	0	1	1	2	0	0	0	1	2	0	0	0	0	1
1951	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	1
1949	-	-	-	0	0	0	1	0	0	0	1	2	0	0	0	1	4	0	0	1	2	3
1948	-	-	-	0	0	0	1	0	0	0	1	3	0	0	1	2	3	0	0	1	2	2
1947	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Total	0	5	11	0	3	4	16	0	1	3	10	38	0	1	3	13	40	0	1	5	12	35
Number of Years of Record	15	15	15	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24

TABLE 3A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT PRESTWICK AIRPORT, AYRSHIRE

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.0	5.5*	0%	15
10 minutes or less	3.3	14.9	22%	15
15 minutes or less	7.3	22.3	33%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	24
15 minutes or less	1.3	3.5*	37%	24
30 minutes or less	1.7	7.3	23%	24
60 minutes or less	6.7	14.6	46%	24
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	24
30 minutes or less	0.4	2.2	18%	24
1 hour or less	1.3	4.4	29%	24
2 hours or less	4.2	8.8	48%	24
4 hours or less	15.8	17.6	90%	24
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	24
1 hour or less	0.4	1.8	22%	24
2 hours or less	1.3	3.6	36%	24
4 hours or less	5.4	7.2	75%	24
8 hours or less	16.7	14.4	116%	24
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	24
2 hours or less	0.4	1.8	22%	24
4 hours or less	2.1	3.6	58%	24
8 hours or less	5.0	7.2	69%	24
16 hours or less	14.6	14.4	101%	24

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Prestwick Airport during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 4

INTENSITIES OF RAINFALL RECORDED AT GLASGOW AIRPORT, RENFREWSHIRE

Number of Days with Specified Amounts of Rain Falling in Specified Times (33 years from 1938 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	2	0	0	0	2	2
1969	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	1	1	0	0	1	1	1
1968	0	1	2	0	1	1	1	0	0	0	0	4	0	0	0	0	4	0	0	0	1	4
1967	0	0	2	0	0	0	2	0	0	1	2	3	0	1	1	1	1	0	1	1	1	2
1966	0	1	1	0	1	1	2	0	0	0	1	6	0	0	0	2	5	0	0	0	4	5
1965	0	1	1	0	0	0	1	0	0	0	0	2	0	0	0	1	2	0	0	0	1	2
1964	1	1	1	0	1	1	1	0	1	1	1	4	1	1	1	1	3	1	1	1	1	3
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
1962	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	2	4	0	0	0	3	4
1961	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	4	0	0	0	2	4
1960	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	3	0	0	0	2	3
1959	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	3	0	0	0	0	2
1958	0	0	0	0	0	0	1	0	0	0	1	2	0	0	0	2	2	0	0	0	1	1
1957	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1956	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	1
1955	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
1954	-	-	-	0	0	0	1	0	0	0	0	3	0	0	0	0	5	0	0	0	1	4
1953	-	-	-	0	1	1	1	1	1	1	1	2	1	1	1	1	3	1	1	1	2	2
1952	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1951	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
1950	-	-	-	0	0	0	1	0	0	0	0	3	0	0	0	2	3	0	0	0	2	3
1949	-	-	-	0	2	3	3	0	1	2	2	5	0	0	1	2	4	0	1	1	3	6
1948	-	-	-	0	0	0	0	0	0	0	0	4	0	0	0	1	2	0	0	0	1	2
1947	-	-	-	0	0	0	1	0	0	0	1	2	0	0	0	0	3	0	0	0	0	2
1946	-	-	-	0	0	1	1	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0

. Contd Overleaf

TABLE 4 (Contd)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1945	-	-	-	0	0	0	0	0	0	0	0	2	0	0	0	1	1	0	0	0	0	2
1944	-	-	-	0	0	0	1	0	0	0	1	2	0	0	0	0	3	0	0	0	0	3
1943	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	1	4
1942	-	-	-	0	0	0	1	0	0	0	0	2	0	0	0	0	4	0	0	0	0	3
1941	-	-	-	0	0	0	0	0	0	0	0	2	0	0	0	1	2	0	0	0	1	2
1940	-	-	-	0	0	0	1	0	0	0	1	4	0	0	0	1	4	0	0	1	2	4
1939	-	-	-	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	0	3
1938	-	-	-	0	0	0	0	0	0	0	0	5	0	0	0	1	3	0	0	0	1	3
Total	1	4	9	0	6	8	19	1	3	6	13	84	2	3	4	24	80	2	4	6	33	83
Number of Years of Record	15	15	15	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33

TABLE 4A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT GLASGOW AIRPORT, RENFREWSHIRE

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.7	5.5*	13%	15
10 minutes or less	2.7	14.9	18%	15
15 minutes or less	6.0	22.3	27%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	33
15 minutes or less	1.8	3.5*	51%	33
30 minutes or less	2.4	7.3	33%	33
60 minutes or less	5.8	14.6	40%	33
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.3	0.9*	33%	33
30 minutes or less	0.9	2.2	41%	33
1 hour or less	1.8	4.4	41%	33
2 hours or less	3.9	8.8	44%	33
4 hours or less	25.5	17.6	145%	33
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.6	0.8*	75%	33
1 hour or less	0.9	1.8	50%	33
2 hours or less	1.2	3.6	33%	33
4 hours or less	7.3	7.2	101%	33
8 hours or less	24.2	14.4	168%	33
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.6	0.9	67%	33
2 hours or less	1.2	1.8	67%	33
4 hours or less	1.8	3.6	50%	33
8 hours or less	10.0	7.2	139%	33
16 hours or less	25.1	14.4	174%	33

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Glasgow Airport during the pericd of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 5

INTENSITIES OF RAINFALL RECORDED AT SLOY POWER STATION, DUNBARTONSHIRE

Number of Days with Specified Amounts of Rain Falling in Specified Times (10 years from 1961 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	2	2	0	1	1	3	0	0	2	3	20	0	0	2	10	25	0	1	1	13	24
1969	0	0	1	0	0	0	4	0	0	0	4	13	0	0	0	4	12	0	0	2	7	15
1968	0	1	2	0	0	0	2	0	0	0	4	12	0	0	1	8	14	0	1	3	8	16
1967	0	0	1	0	0	0	3	0	0	0	5	29	0	0	0	12	25	0	0	2	19	30
1966	0	1	2	0	0	0	2	0	0	0	1	14	0	0	0	8	19	0	0	2	9	20
1965	1	1	1	0	1	1	3	1	1	1	4	20	1	1	2	8	19	1	1	4	11	9
1964	0	1	3	0	0	0	4	0	0	1	4	14	0	0	2	5	16	0	0	3	9	15
1963	0	0	2	0	0	0	3	0	0	0	5	18	0	0	0	5	16	0	0	5	9	17
1962	0	0	0	0	0	0	1	0	0	0	4	21	0	0	0	11	25	0	0	4	18	24
1961	0	0	0	0	0	0	2	0	0	0	2	24	0	0	1	7	31	0	0	3	17	32
Total	1	6	14	0	2	2	27	1	1	4	36	185	1	1	8	78	202	1	3	29	120	202
Number of Years of Record	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

TABLE 5A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT SLOY POWER STATION, DUNBARTONSHIRE

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	1.0	5.5*	18%	10
10 minutes or less	6.0	14.9	40%	10
15 minutes or less	14.0	22.3	63%	10
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	10
15 minutes or less	2.0	3.5*	57%	10
30 minutes or less	2.0	7.3	27%	10
60 minutes or less	27.0	14.6	185%	10
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	1.0	0.9*	111%	10
30 minutes or less	1.0	2.2	45%	10
1 hour or less	4.0	4.4	91%	10
2 hours or less	36.0	8.8	409%	10
4 hours or less	185.0	17.6	1051%	10
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	1.0	0.8*	125%	10
1 hour or less	1.0	1.8	55%	10
2 hours or less	8.0	3.6	222%	10
4 hours or less	78.0	7.2	1083%	10
8 hours or less	202.0	14.4	1403%	10
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	1.0	0.9	111%	10
2 hours or less	3.0	1.8	167%	10
4 hours or less	29.0	3.6	805%	10
8 hours or less	120.0	7.2	1667%	10
16 hours or less	202.0	14.4	1403%	10

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Sloy Power Station, Dunbartonshire during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 6

INTENSITIES OF RAINFALL RECORDED AT MACHRIHANISH, MULL OF KINTYRE, ARGYLL

Number of Days with Specified Amounts of Rain Falling in Specified Times (6 years from 1965 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1	3	0	0	0	1	3
1969	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	1	2	0	0	0	2	2
1968	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	2	0	0	0	2	4
1967	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1	3	0	0	0	1	3
1966	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0
1965	0	1	1	0	0	0	0	0	0	0	0	4	0	0	0	1	2	0	0	0	1	2
Total	0	1	2	0	0	0	1	0	0	0	0	17	0	0	0	6	14	0	0	0	7	14
Number of Years of Record	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

TABLE 6A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT MACHRIHANISH, MULL OF KINTYRE, ARGYLL

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.0	5.5*	0%	6
10 minutes or less	1.7	14.9	11%	6
15 minutes or less	3.3	22.3	15%	6
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	6
15 minutes or less	0.0	3.5*	0%	6
30 minutes or less	0.0	7.3	0%	6
60 minutes or less	1.7	14.6	12%	6
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	6
30 minutes or less	0.0	2.2	0%	6
1 hour or less	0.0	4.4	0%	6
2 hours or less	0.0	8.8	0%	6
4 hours or less	28.3	17.6	161%	6
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	6
1 hour or less	0.0	1.8	0%	6
2 hours or less	0.0	3.6	0%	6
4 hours or less	10.0	7.2	139%	6
8 hours or less	23.3	14.4	162%	6
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	6
2 hours or less	0.0	1.8	0%	6
4 hours or less	0.0	3.6	0%	6
8 hours or less	11.7	7.2	163%	6
16 hours or less	23.3	14.4	162%	6

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Machrihanish during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 7

Intensities of rainfall recorded at Kinlochewe, Ross and Cromarty

Number of days with specified amounts of rain falling in specified times (6 years from 1965 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	1	1	2	0	0	1	3	0	0	0	3	12	0	0	0	4	12	0	0	3	7	14
1969	0	0	0	0	0	0	1	0	0	0	1	6	0	0	1	1	4	0	0	1	1	7
1968	1	1	1	0	0	1	2	0	0	0	2	7	0	0	0	5	8	0	0	1	5	7
1967	0	0	0	0	0	0	1	0	0	0	2	14	0	0	0	6	12	0	0	2	8	15
1966	0	0	0	0	0	0	1	0	0	0	3	7	0	0	0	4	8	0	0	3	5	8
1965	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	5	10	0	0	0	6	8
Total	2	2	3	0	0	2	8	0	0	0	11	58	0	0	1	25	54	0	0	10	32	59
Number of years of record	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

TABLE 7A

Comparison of observed and estimated intensities of rainfall at Kinlochewe, Ross and Cromarty

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed frequency (number of days in 10 years)	B. Estimated frequency (number of days in 10 years)	C. Observed frequency as percentage of estimated frequency	D. Period of record used for calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	3.3	5.5*	60%	6
10 minutes or less	3.3	14.9	22%	6
15 minutes or less	5.0	22.3	22%	6
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	6
15 minutes or less	0.0	3.5*	0%	6
30 minutes or less	3.3	7.3	45%	6
60 minutes or less	13.3	14.6	91%	6
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	6
30 minutes or less	0.0	2.2	0%	6
1 hour or less	0.0	4.4	0%	6
2 hours or less	18.3	8.8	208%	6
4 hours or less	96.7	17.6	549%	6
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	6
1 hour or less	0.0	1.8	0%	6
2 hours or less	1.7	3.6	47%	6
4 hours or less	41.7	7.2	579%	6
8 hours or less	90.0	14.4	625%	6
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	6
2 hours or less	0.0	1.8	0%	6
4 hours or less	16.7	3.6	464%	6
8 hours or less	53.3	7.2	740%	6
16 hours or less	98.3	14.4	683%	6

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Kinlochewe during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 8

INTENSITIES OF RAINFALL RECORDED AT TIREE, INNER HEBRIDES, ARGYLL

Number of Days with Specified Amounts of Rain Falling in Specified Times (17 years from 1954 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	0	0	0	0	1	0	0	0	1	2	0	0	0	1	2	0	0	0	2	3
1969	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1
1968	0	1	2	0	0	0	0	0	0	0	0	4	0	0	0	0	3	0	0	0	1	2
1967	1	3	4	0	0	1	4	0	0	1	2	5	0	0	0	1	5	0	0	0	2	3
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	1	2	0	0	1	3	0	0	0	1	6	0	0	0	3	5	0	0	0	4	5
1964	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
1963	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1962	0	0	1	0	0	0	1	0	0	0	1	3	0	0	0	1	2	0	0	1	2	3
1961	0	0	1	0	0	0	1	0	0	0	1	3	0	0	0	1	2	0	0	0	1	4
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	1	1	0	0	0	1	0	0	0	0	3	0	0	0	0	5	0	0	0	0	2
1958	0	0	1	0	0	0	1	0	0	0	1	3	0	0	1	2	4	0	0	1	1	3
1957	0	0	0	0	0	0	1	0	0	0	1	3	0	0	0	0	2	0	0	0	0	2
1956	0	0	2	0	0	0	3	0	0	0	3	5	0	0	2	3	5	0	0	3	4	5
1955	-	-	-	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0	0	0	0	2
1954	-	-	-	0	0	0	1	0	0	1	1	3	0	0	1	1	5	0	0	1	1	5
Total	1	7	17	0	0	2	18	0	0	2	12	43	0	0	4	13	46	0	0	6	18	42
Number of Years of Record	15	15	15	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17

TABLE 8A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT TIREE, INNER HEBRIDES, ARGYLL

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.7	5.5*	13%	15
10 minutes or less	4.7	14.9	32%	15
15 minutes or less	11.3	22.3	51%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	17
15 minutes or less	0.0	3.5*	0%	17
30 minutes or less	1.2	7.3	16%	17
60 minutes or less	10.6	14.6	73%	17
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	17
30 minutes or less	0.0	2.2	0%	17
1 hour or less	1.2	4.4	27%	17
2 hours or less	7.1	8.8	81%	17
4 hours or less	25.3	17.6	144%	17
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	17
1 hour or less	0.0	1.8	0%	17
2 hours or less	2.3	3.6	64%	17
4 hours or less	7.6	7.2	106%	17
8 hours or less	27.1	14.4	188%	17
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	17
2 hours or less	0.0	1.8	0%	17
4 hours or less	3.5	3.6	97%	17
8 hours or less	10.6	7.2	147%	17
16 hours or less	24.7	14.4	172%	17

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Tiree during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 9

Intensities of rainfall recorded at Isle of Rhum, Inner Hebrides

Number of days with specified amounts of rain falling in specified times (9 years from 1962 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	1	1	0	0	1	1	0	0	0	3	17	0	0	1	6	16	0	0	2	8	16
1969	1	3	3	0	0	1	7	0	0	1	8	20	0	0	1	12	19	0	0	6	13	20
1968	0	1	1	0	0	1	5	0	0	1	6	17	0	0	1	5	15	0	0	3	8	14
1967	0	2	2	0	0	1	5	0	0	1	8	23	0	1	2	7	24	0	1	5	13	22
1966	0	1	1	0	0	1	6	0	0	0	3	21	0	0	1	8	18	0	0	2	12	16
1965	0	0	1	0	0	0	6	0	0	0	5	25	0	1	1	9	25	0	0	4	13	24
1964	0	1	1	0	0	0	2	0	0	0	4	15	0	0	0	6	16	0	0	1	9	15
1963	0	1	1	0	0	0	1	0	0	0	1	13	0	0	0	5	17	0	0	0	8	15
1962	0	0	3	0	0	0	7	0	0	1	8	22	0	0	4	11	23	0	0	4	12	21
Total	1	10	14	0	0	5	40	0	0	4	46	173	0	2	11	69	173	0	1	27	96	163
Number of years of record	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9

TABLE 9A

Comparison of observed and estimated intensities of rainfall at Isle of Rhum, Inner Hebrides

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed frequency (number of days in 10 years)	B. Estimated frequency (number of days in 10 years)	C. Observed frequency as percentage of estimated frequency	D. Period of Record used for calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	1.1	5.5*	20%	9
10 minutes or less	11.1	14.9	75%	9
15 minutes or less	15.5	22.3	70%	9
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	9
15 minutes or less	0.0	3.5*	0%	9
30 minutes or less	5.5	7.3	75%	9
60 minutes or less	44.4	14.6	302%	9
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	9
30 minutes or less	0.0	2.2	0%	9
1 hour or less	4.4	4.4	100%	9
2 hours or less	51.1	8.8	581%	9
4 hours or less	192.2	17.6	1092%	9
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	9
1 hour or less	2.2	1.8	122%	9
2 hours or less	12.2	3.6	339%	9
4 hours or less	76.7	7.2	1065%	9
8 hours or less	192.2	14.4	1335%	9
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	9
2 hours or less	1.1	1.8	61%	9
4 hours or less	30.0	3.6	833%	9
8 hours or less	106.7	7.2	1482%	9
16 hours or less	181.1	14.4	1258%	9

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Isle of Rhum during the period of years shown in Column 'D'

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 10

INTENSITIES OF RAINFALL RECORDED AT STORNOWAY, OUTER HEBRIDES, ROSS & CROMARTY

Number of Days with Specified Amounts of Rain Falling in Specified Times (17 years from 1954 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	1	2
1969	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
1964	0	1	2	0	0	0	1	0	0	0	1	3	0	0	0	0	3	0	0	0	0	1
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
1961	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	1	2
1960	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	1	0	0	0	1	3	0	0	0	2	5	0	0	1	2	4
1958	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	1
1957	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	0	0	0	1	3
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
1955	-	-	-	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
1954	-	-	-	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1
Total	0	1	3	0	0	1	4	0	0	0	3	17	0	0	0	3	23	0	0	1	5	20
Number of Years of Record	15	15	15	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17

TABLE 10A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT STORNOWAY, OUTER HEBRIDES, ROSS & CROMARTY

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.0	5.5*	0%	15
10 minutes or less	0.7	14.9	5%	15
15 minutes or less	2.0	22.3	9%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	17
15 minutes or less	0.0	3.5*	0%	17
30 minutes or less	0.6	7.3	8%	17
60 minutes or less	2.3	14.6	16%	17
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	17
30 minutes or less	0.0	2.2	0%	17
1 hour or less	0.0	4.4	0%	17
2 hours or less	1.8	8.8	20%	17
4 hours or less	10.0	17.6	57%	17
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	17
1 hour or less	0.0	1.8	0%	17
2 hours or less	0.0	3.6	0%	17
4 hours or less	1.8	7.2	25%	17
8 hours or less	13.5	14.4	94%	17
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	17
2 hours or less	0.0	1.8	0%	17
4 hours or less	0.6	3.6	17%	17
8 hours or less	2.9	7.2	40%	17
16 hours or less	11.8	14.4	82%	17

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Stornoway during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp.\left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 11

INTENSITIES OF RAINFALL RECORDED AT BENBECULA, OUTER HEBRIDES, INVERNESS-SHIRE

Number of Days with Specified Amounts of Rain Falling in Specified Times (17 years from 1954 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	1	0	0	0	1	0	0	0	1	3	0	0	0	0	2	0	0	0	1	2
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
1968	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
1967	0	1	1	0	0	1	1	0	0	0	1	2	0	0	0	0	2	0	0	0	0	2
1966	0	0	0	0	0	0	3	0	0	0	2	3	0	0	0	0	4	0	0	0	0	2
1965	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	2
1964	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	4
1963	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
1961	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	1	1	0	0	0	0	2
1960	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	1	0	0	0	1	3	0	0	0	1	1	0	0	0	1	1
1958	1	1	1	0	1	1	1	0	0	1	1	3	0	0	1	2	2	0	0	0	0	3
1957	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	1	5
1956	0	0	1	0	0	0	1	0	0	0	1	2	0	0	1	2	3	0	0	1	1	8
1955	-	-	-	0	1	1	2	0	0	1	1	3	0	0	0	1	2	0	0	1	1	1
1954	-	-	-	0	0	0	0	0	0	0	0	3	0	0	0	1	3	0	0	0	2	3
Total	2	4	8	0	2	4	14	0	0	2	8	31	0	0	2	8	32	0	0	2	7	38
Number of Years of Record	15	15	15	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17

TABLE 11A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT BENBECULA, OUTER HEBRIDES, INVERNESS-SHIRE

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	1.3	5.5*	24%	15
10 minutes or less	2.7	14.9	18%	15
15 minutes or less	5.3	22.3	24%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	17
15 minutes or less	1.2	3.5*	34%	17
30 minutes or less	2.3	7.3	32%	17
60 minutes or less	8.2	14.6	56%	17
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	17
30 minutes or less	0.0	2.2	0%	17
1 hour or less	1.2	4.4	27%	17
2 hours or less	4.7	8.8	53%	17
4 hours or less	18.2	17.6	103%	17
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	17
1 hour or less	0.0	1.8	0%	17
2 hours or less	1.2	3.6	33%	17
4 hours or less	4.7	7.2	65%	17
8 hours or less	18.8	14.4	131%	17
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	17
2 hours or less	0.0	1.8	0%	17
4 hours or less	1.2	3.6	33%	17
8 hours or less	4.1	7.2	57%	17
16 hours or less	22.3	14.4	155%	17

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Benbecula during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 12

INTENSITIES OF RAINFALL RECORDED AT LERWICK, SHETLAND

Number of Days with Specified Amounts of Rain Falling in Specified Times (17 years from 1954 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	4	0	0	0	2	5
1969	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	0	0	0	1	3
1968	0	1	1	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	1
1967	1	2	3	0	0	1	2	0	0	1	1	2	0	1	1	1	3	0	1	1	1	4
1966	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
1965	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	1
1964	0	1	1	0	0	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	1	1
1963	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	3
1962	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	2
1961	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	2
1960	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
1959	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0	0	0	1	3
1957	0	0	0	0	0	0	1	0	0	0	1	2	0	0	0	0	1	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
1955	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	-	-	-	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0	0	0	0	2
Total	1	4	5	0	0	1	5	0	0	1	3	26	0	1	1	4	31	0	1	1	7	32
Number of Years of Record	15	15	15	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17

TABLE 12A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT LERWICK, SHETLAND

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.7	5.5*	13%	15
10 minutes or less	2.7	14.9	18%	15
15 minutes or less	3.3	22.3	15%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	17
15 minutes or less	0.0	3.5*	0%	17
30 minutes or less	0.6	7.3	8%	17
60 minutes or less	2.9	14.6	20%	17
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	17
30 minutes or less	0.0	2.2	0%	17
1 hour or less	0.6	4.4	14%	17
2 hours or less	1.8	8.8	20%	17
4 hours or less	15.3	17.6	87%	17
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	17
1 hour or less	0.6	1.8	33%	17
2 hours or less	0.6	3.6	17%	17
4 hours or less	2.3	7.2	32%	17
8 hours or less	18.2	14.4	126%	17
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	17
2 hours or less	0.6	1.8	33%	17
4 hours or less	0.6	3.6	17%	17
8 hours or less	4.1	7.2	57%	17
16 hours or less	18.8	14.4	130%	17

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Lerwick during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp.\left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 13

INTENSITIES OF RAINFALL RECORDED AT KIRKWALL AIRPORT, ORKNEY

Number of Days with Specified Amounts of Rain Falling in Specified Times (24 years from 1947 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	1	2	0	0	0	1	4
1969	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	1
1968	0	0	1	0	0	0	2	0	0	0	0	2	0	0	0	0	2	0	0	0	2	2
1967	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	1	1
1966	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	4
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
1962	0	1	1	0	0	0	1	0	0	0	0	1	0	0	0	0	2	0	0	0	1	1
1961	0	1	1	0	0	1	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
1960	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	1	1
1957	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	4	0	0	0	2	5
1956	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
1955	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
1954	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
1953	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
1952	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1
1951	-	-	-	0	0	0	0	0	0	0	0	2	0	0	0	1	1	0	0	0	0	0
1950	-	-	-	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	1	1
1949	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1948	-	-	-	0	0	0	2	0	0	0	2	2	0	0	0	0	2	0	0	0	0	1
1947	-	-	-	0	0	1	1	0	0	1	1	1	0	0	1	1	1	0	0	1	1	1
Total	0	2	5	0	0	2	8	0	0	1	4	28	0	0	1	4	29	0	0	1	11	31
Number of Years of Record	15	15	15	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24

TABLE 13A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT KIRKWALL AIRPORT, ORKNEY

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.0	5.5*	0%	15
10 minutes or less	1.3	14.9	9%	15
15 minutes or less	3.3	22.3	15%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	24
15 minutes or less	0.0	3.5*	0%	24
30 minutes or less	0.8	7.3	11%	24
60 minutes or less	3.3	14.6	23%	24
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	24
30 minutes or less	0.0	2.2	0%	24
1 hour or less	0.4	4.4	9%	24
2 hours or less	1.7	8.8	19%	24
4 hours or less	11.7	17.6	66%	24
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	24
1 hour or less	0.0	1.8	0%	24
2 hours or less	0.4	3.6	11%	24
4 hours or less	1.7	7.2	24%	24
8 hours or less	12.1	14.4	84%	24
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	24
2 hours or less	0.0	1.8	0%	24
4 hours or less	0.4	3.6	11%	24
8 hours or less	4.6	7.2	64%	24
16 hours or less	12.9	14.4	90%	24

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Kirkwall Airport during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 14

INTENSITIES OF RAINFALL RECORDED AT WICK, CAITHNESS

Number of Days with Specified Amounts of Rain Falling in Specified Times (23 years from 1948 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	0	3
1969	0	0	0	0	0	0	1	0	0	0	1	2	0	0	0	0	4	0	0	0	0	3
1968	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0	0	0	1
1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
1966	1	2	4	0	1	2	3	0	0	0	2	2	0	0	0	2	4	0	0	0	0	4
1965	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	4
1964	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1	0	0	1	1	3
1963	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	3	0	0	0	1	3
1962	0	1	2	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
1960	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
1958	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1
1956	0	1	1	0	0	1	1	0	0	0	1	1	0	0	0	1	2	0	0	0	0	1
1955	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	1
1953	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1952	-	-	-	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1951	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
1950	-	-	-	0	0	1	1	0	0	0	1	1	0	0	0	0	1	0	0	0	1	1
1949	-	-	-	0	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0
1948	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	4	10	0	1	4	12	0	0	0	8	21	0	0	0	6	29	0	0	1	4	30
Number of Years of Record	15	15	15	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23

TABLE 14A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT WICK, CAITHNESS

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.7	5.5*	13%	15
10 minutes or less	2.7	14.9	18%	15
15 minutes or less	6.7	22.3	30%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	23
15 minutes or less	0.4	3.5*	11%	23
30 minutes or less	1.7	7.3	23%	23
60 minutes or less	5.2	14.6	36%	23
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	23
30 minutes or less	0.0	2.2	0%	23
1 hour or less	0.0	4.4	0%	23
2 hours or less	3.5	8.8	40%	23
4 hours or less	9.1	17.6	52%	23
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	23
1 hour or less	0.0	1.8	0%	23
2 hours or less	0.0	3.6	0%	23
4 hours or less	2.6	7.2	36%	23
8 hours or less	12.6	14.4	87%	23
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	23
2 hours or less	0.0	1.8	0%	23
4 hours or less	0.4	3.6	11%	23
8 hours or less	1.7	7.2	24%	23
16 hours or less	13.0	14.4	90%	23

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Wick during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 15

INTENSITIES OF RAINFALL RECORDED AT MULLARDOCH DAM, INVERNESS-SHIRE

Number of days with specified amounts of rain falling in specified times (8 years from 1963 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	1	1	0	0	0	1	0	0	0	2	11	0	0	1	4	10	0	0	1	6	10
1969	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	2	4	0	0	0	2	5
1968	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	1	8	0	0	0	5	9
1967	0	0	1	0	0	1	11	0	0	1	2	10	0	0	1	3	10	0	0	2	7	12
1966	0	0	0	0	0	0	1	0	0	0	1	4	0	0	1	1	4	0	0	1	1	5
1965	0	0	0	0	0	0	0	0	0	0	1	5	0	0	0	3	8	0	0	1	6	11
1964	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	3	0	0	1	2	5
1963	0	1	1	0	0	0	0	0	0	0	0	3	0	0	0	0	4	0	0	0	1	3
Total	0	2	3	0	0	1	13	0	0	1	6	45	0	0	3	15	51	0	0	6	30	60
Number of Years of Record	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8

TABLE 15A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT MULLARDOCH DAM, INVERNESS-SHIRE

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.0	5.5*	0%	8
10 minutes or less	2.5	14.9	17%	8
15 minutes or less	3.7	22.3	17%	8
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	8
15 minutes or less	0.0	3.5*	0%	8
30 minutes or less	1.3	7.3	18%	8
60 minutes or less	16.3	14.6	112%	8
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	8
30 minutes or less	0.0	2.2	0%	8
1 hour or less	1.3	4.4	29%	8
2 hours or less	7.5	8.8	85%	8
4 hours or less	56.3	17.6	320%	8
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	8
1 hour or less	0.0	1.8	0%	8
2 hours or less	3.7	3.6	103%	8
4 hours or less	18.7	7.2	260%	8
8 hours or less	63.7	14.4	442%	8
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	8
2 hours or less	0.0	1.8	0%	8
4 hours or less	7.5	3.6	208%	8
8 hours or less	37.5	7.2	521%	8
16 hours or less	75.0	14.4	521%	8

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Mullardoch Dam during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 16

INTENSITIES OF RAINFALL RECORDED AT DALCROSS (INVERNESS) AIRPORT, INVERNESS-SHIRE

Number of Days with Specified Amounts of Rain Falling in Specified Times (10 years from 1961 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	0	0	0	2	2
1969	0	0	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	3	0	0	0	1	3
1967	0	0	1	0	0	0	2	0	0	0	2	3	0	0	1	2	2	0	0	2	2	2
1966	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	1	3
1965	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1	0	0	1	1	2
1964	0	0	1	0	0	1	1	0	0	1	1	2	0	0	1	1	2	0	0	0	0	2
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
1961	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
Total	0	0	3	0	0	1	6	0	0	1	5	11	0	0	2	6	17	0	0	3	7	20
Number of Years of Record	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

TABLE 16A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT DALCROSS (INVERNESS) AIRPORT, INVERNESS-SHIRE

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.0	5.5*	0%	10
10 minutes or less	0.0	14.9	0%	10
15 minutes or less	3.0	22.3	13%	10
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	10
15 minutes or less	0.0	3.5*	0%	10
30 minutes or less	1.0	7.3	14%	10
60 minutes or less	6.0	14.6	41%	10
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	10
30 minutes or less	0.0	2.2	0%	10
1 hour or less	1.0	4.4	23%	10
2 hours or less	5.0	8.8	57%	10
4 hours or less	11.0	17.6	63%	10
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	10
1 hour or less	0.0	1.8	0%	10
2 hours or less	2.0	3.6	55%	10
4 hours or less	6.0	7.2	83%	10
8 hours or less	17.0	14.4	118%	10
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	10
2 hours or less	0.0	1.8	0%	10
4 hours or less	3.0	3.6	83%	10
8 hours or less	7.0	7.2	97%	10
16 hours or less	20.0	14.4	139%	10

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Dalcross (Inverness) Airport during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

but the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 17

INTENSITIES OF RAINFALL RECORDED AT KINLOSS, MORAYSHIRE

Number of Days with Specified Amounts of Rain Falling in Specified Times (20 years from 1951 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	2
1969	1	3	3	0	0	2	2	0	0	0	1	2	0	0	0	0	0	0	0	0	0	1
1968	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1967	0	0	0	0	0	0	1	0	0	0	2	3	0	0	1	2	4	0	0	1	2	2
1966	0	1	3	0	1	1	1	0	0	1	1	4	0	0	0	1	3	0	0	0	2	4
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	2	0	0	0	2	2
1962	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
1961	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0
1960	0	1	2	0	0	0	1	0	0	0	1	5	0	0	0	1	3	0	0	0	2	2
1959	0	1	1	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
1958	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
1957	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1
1956	0	1	2	0	0	0	0	0	0	0	0	3	0	0	0	1	2	0	0	1	2	3
1955	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	-	-	-	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	2
1953	-	-	-	0	1	2	2	0	1	1	1	3	0	0	1	1	2	0	0	0	1	2
1952	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Total	1	8	14	0	2	6	9	0	1	2	7	30	0	0	2	7	25	0	0	2	12	26
Number of Years of Record	15	15	15	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

TABLE 17A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT KINLOSS, MORAYSHIRE

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.7	5.5*	13%	15
10 minutes or less	5.3	14.9	36%	15
15 minutes or less	9.3	22.3	42%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	20
15 minutes or less	1.0	3.5*	29%	20
30 minutes or less	3.0	7.3	41%	20
60 minutes or less	4.5	14.6	31%	20
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	20
30 minutes or less	0.5	2.2	23%	20
1 hour or less	1.0	4.4	23%	20
2 hours or less	3.5	8.8	40%	20
4 hours or less	15.0	17.6	85%	20
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	20
1 hour or less	0.0	1.8	0%	20
2 hours or less	1.0	3.6	28%	20
4 hours or less	3.5	7.2	49%	20
8 hours or less	12.5	14.4	87%	20
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	20
2 hours or less	0.0	1.8	0%	20
4 hours or less	1.0	3.6	28%	20
8 hours or less	6.0	7.2	83%	20
16 hours or less	13.0	14.4	90%	20

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Kinloss during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 18

INTENSITIES OF RAINFALL RECORDED AT DYCE (ABERDEEN) AIRPORT, ABERDEENSHIRE

Number of Days with Specified Amounts of Rain Falling in Specified Times (25 years from 1946 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1	5	0	0	1	3	7
1969	0	2	2	0	1	1	2	0	1	1	1	3	0	0	0	1	4	0	0	1	2	4
1968	0	2	3	0	0	0	2	0	0	0	0	4	0	0	0	1	3	0	0	0	0	2
1967	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	3
1966	0	1	1	0	0	0	1	0	0	0	1	3	0	0	0	2	3	0	0	1	2	4
1965	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
1964	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	4	0	0	0	0	4
1963	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	2	0	0	0	1	2
1962	0	0	0	0	0	0	1	0	0	0	2	5	0	0	0	3	5	0	0	0	2	6
1961	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
1960	0	2	2	0	0	1	1	0	0	0	0	2	0	0	0	0	2	0	0	0	1	3
1959	0	1	2	0	0	0	2	0	0	0	1	4	0	0	0	1	2	0	0	0	2	2
1958	1	3	3	0	0	0	2	0	0	0	1	4	0	0	0	2	4	0	0	0	2	3
1957	2	2	3	0	0	2	3	0	0	0	0	2	0	0	0	1	5	0	0	0	3	5
1956	0	1	1	0	0	0	0	0	0	0	2	3	0	0	0	2	3	0	0	0	2	3
1955	-	-	-	0	0	0	1	0	0	0	1	3	0	0	0	1	1	0	0	0	0	1
1954	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	2
1953	-	-	-	0	0	1	2	0	1	1	1	2	0	0	1	1	2	0	1	1	2	2
1952	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
1951	-	-	-	0	0	0	1	0	0	0	1	4	0	0	0	1	4	0	0	1	4	5
1950	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	3
1949	-	-	-	0	0	0	1	0	0	0	1	2	0	0	0	0	2	0	0	0	0	2
1948	-	-	-	0	1	1	1	1	1	1	1	4	1	1	1	2	5	0	0	0	2	4
1947	-	-	-	0	0	0	0	0	0	0	0	4	0	0	0	0	4	0	0	0	0	2
1946	-	-	-	0	1	1	2	1	1	1	2	4	1	1	1	2	3	0	0	1	1	2
Total	3	14	19	0	3	7	24	2	4	4	15	65	2	2	3	22	75	0	1	6	29	72
Number of Years of Record	15	15	15	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25

TABLE 18A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT DYCE (ABERDEEN) AIRPORT, ABERDEENSHIRE

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	2.0	5.5*	36%	15
10 minutes or less	9.3	14.9	62%	15
15 minutes or less	12.7	22.3	57%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	25
15 minutes or less	1.2	3.5*	34%	25
30 minutes or less	2.8	7.3	38%	25
60 minutes or less	9.6	14.6	66%	25
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.8	0.9*	89%	25
30 minutes or less	1.6	2.2	73%	25
1 hour or less	1.6	4.4	36%	25
2 hours or less	6.0	8.8	68%	25
4 hours or less	26.0	17.6	148%	25
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.8	0.8*	100%	25
1 hour or less	0.8	1.8	44%	25
2 hours or less	1.2	3.6	33%	25
4 hours or less	8.8	7.2	122%	25
8 hours or less	30.0	14.4	208%	25
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	25
2 hours or less	0.4	1.8	22%	25
4 hours or less	2.4	3.6	67%	25
8 hours or less	11.6	7.2	161%	25
16 hours or less	28.8	14.4	200%	25

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Dyce (Aberdeen) Airport during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 19

INTENSITIES OF RAINFALL RECORDED AT LEUCHARS, FIFE

Number of Days with Specified Amounts of Rain Falling in Specified Times (34 years from 1937 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	2	3	3	0	2	2	2	0	1	1	1	2	0	0	0	2	2	0	0	1	1	1
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
1968	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	1	3	0	0	0	2	4
1967	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	1	2	0	0	1	2	6
1965	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
1964	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	1	0	0	0	1	3	0	0	0	1	3	0	0	0	0	2
1962	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	1	4	0	0	0	1	1
1961	0	1	1	0	0	1	1	0	0	0	2	3	0	0	0	1	3	0	0	1	2	3
1960	1	2	3	0	1	1	1	0	1	1	1	4	0	1	1	2	4	0	0	0	3	5
1959	0	2	2	0	0	0	0	0	0	0	1	1	0	0	0	0	2	0	0	0	1	2
1958	0	0	1	0	0	0	1	0	0	0	1	1	0	0	0	1	2	0	0	1	1	1
1957	0	0	1	0	0	1	2	0	0	0	0	3	0	0	0	1	3	0	0	0	1	2
1956	0	1	1	0	0	0	1	0	0	0	1	3	0	0	0	1	2	0	0	0	1	1
1955	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1954	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	1	1
1953	-	-	-	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1952	-	-	-	0	0	0	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	1
1951	-	-	-	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
1950	-	-	-	0	0	0	1	0	0	1	1	1	0	1	1	1	3	0	1	1	1	2
1949	-	-	-	0	1	2	4	0	0	1	2	4	0	0	2	2	3	0	0	2	2	3
1948	-	-	-	0	0	0	0	0	0	0	0	5	0	0	0	0	3	0	0	0	0	2
1947	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
1946	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1

Contd Overleaf

TABLE 19 (Contd)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1945	-	-	-	0	0	0	1	0	0	0	0	3	0	0	0	0	3	0	0	0	0	2
1944	-	-	-	0	1	1	1	0	0	1	1	1	0	0	1	1	1	0	0	0	0	1
1943	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1942	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1941	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1940	-	-	-	0	0	0	1	0	0	0	1	2	0	0	0	2	3	0	0	0	1	3
1939	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
1938	-	-	-	0	1	2	3	1	1	1	2	4	0	0	0	2	2	0	0	0	2	3
1937	-	-	-	0	0	0	1	0	0	0	2	3	0	0	0	1	4	0	0	1	1	3
Total	3	9	15	0	7	11	26	1	3	6	19	57	0	2	5	22	61	0	1	8	25	59
Number of Years of Record	15	15	15	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34

TABLE 19A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT LEUCHARS, FIFE

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	2.0	5.5*	36%	15
10 minutes or less	6.0	14.9	40%	15
15 minutes or less	10.0	22.3	45%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	34
15 minutes or less	2.1	3.5*	60%	34
30 minutes or less	3.2	7.3	44%	34
60 minutes or less	7.6	14.6	52%	34
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.3	0.9*	33%	34
30 minutes or less	0.9	2.2	41%	34
1 hour or less	1.8	4.4	41%	34
2 hours or less	5.6	8.8	64%	34
4 hours or less	16.8	17.6	95%	34
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	34
1 hour or less	0.6	1.8	33%	34
2 hours or less	1.5	3.6	42%	34
4 hours or less	6.5	7.2	90%	34
8 hours or less	17.9	14.4	124%	34
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	34
2 hours or less	0.3	1.8	17%	34
4 hours or less	2.3	3.6	64%	34
8 hours or less	7.3	7.2	101%	34
16 hours or less	17.3	14.4	120%	34

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Leuchars during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp.\left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 20

INTENSITIES OF RAINFALL RECORDED AT STRONACHLACHAR, LOCH KATRINE, STIRLINGSHIRE

Number of Days with Specified Amounts of Rain falling in specified times (12 years from 1959 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	1	3	5	0	0	1	5	0	0	0	4	18	0	0	0	6	23	0	0	1	9	24
1969	0	1	1	0	0	0	2	0	0	0	2	7	0	0	0	1	5	0	0	1	3	6
1968	0	1	4	0	0	1	4	0	0	0	2	12	0	0	0	5	15	0	0	2	8	16
1967	0	1	1	0	0	0	4	0	0	0	3	14	0	0	1	5	12	0	0	3	7	14
1966	1	1	1	0	0	0	1	0	0	0	3	12	0	0	0	4	13	0	0	2	5	15
1965	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	5	15	0	0	1	6	16
1964	0	0	1	0	0	0	2	0	0	0	2	9	0	0	0	3	8	0	0	1	4	9
1963	0	0	2	0	0	0	1	0	0	0	1	10	0	0	0	5	11	0	0	1	7	12
1962	0	0	0	0	0	0	1	0	0	0	4	13	0	0	1	6	18	0	0	4	9	22
1961	0	1	1	0	0	0	0	0	0	0	0	12	0	0	0	6	20	0	0	3	9	22
1960	0	0	1	0	0	0	1	0	0	0	0	9	0	0	0	3	11	0	0	0	5	14
1959	1	1	1	0	0	0	0	0	0	0	1	9	0	0	0	0	10	0	0	0	5	9
Total	3	9	18	0	0	2	21	0	0	0	22	137	0	0	2	49	161	0	0	19	77	179
Number of Years of Record	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12

TABLE 20A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT STRONACHLACHAR, LOCH KATRINE, STIRLINGSHIRE

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	2.5	5.5*	45%	12
10 minutes or less	7.5	14.9	50%	12
15 minutes or less	15.0	22.3	67%	12
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	12
15 minutes or less	0.0	3.5*	0%	12
30 minutes or less	1.7	7.3	23%	12
60 minutes or less	17.5	14.6	120%	12
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	12
30 minutes or less	0.0	2.2	0%	12
1 hour or less	0.0	4.4	0%	12
2 hours or less	18.3	8.8	208%	12
4 hours or less	114.2	17.6	649%	12
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	12
1 hour or less	0.0	1.8	0%	12
2 hours or less	1.7	3.6	47%	12
4 hours or less	40.8	7.2	567%	12
8 hours or less	134.2	14.4	932%	12
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	12
2 hours or less	0.0	1.8	0%	12
4 hours or less	15.8	3.6	439%	12
8 hours or less	64.2	7.2	892%	12
16 hours or less	149.2	14.4	1036%	12

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Stronachlachar during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 21

INTENSITIES OF RAINFALL RECORDED AT CUMBERNAULD, EAST DUNBARTONSHIRE

Number of Days with Specified Amounts of Rain falling in specified times (10 years from 1961 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	1	0	0	0	0	0	0	0	0	4	0	0	0	0	4	0	0	0	1	4
1969	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	2	0	0	0	2	2
1968	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	3
1967	0	0	0	0	0	0	3	0	0	0	1	4	0	0	0	2	2	0	0	0	1	1
1966	0	0	0	0	0	0	1	0	0	0	0	6	0	0	0	3	3	0	0	1	3	4
1965	0	1	1	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	0	2
1964	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	1	2	0	0	0	0	0
1963	0	0	3	0	0	0	1	0	0	0	1	4	0	0	0	0	2	0	0	0	0	2
1962	0	0	1	0	0	0	1	0	0	0	1	4	0	0	0	2	5	0	0	1	2	5
1961	0	1	1	0	0	0	1	0	0	0	2	4	0	0	0	2	6	0	0	2	4	5
Total	0	2	8	0	0	0	7	0	0	0	6	33	0	0	0	11	31	0	0	4	13	28
Number of Years of Record	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

TABLE 21A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT CUMBERNAULD, EAST DUNBARTONSHIRE

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.0	5.5*	0%	10
10 minutes or less	2.0	14.9	13%	10
15 minutes or less	8.0	22.3	36%	10
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	10
15 minutes or less	0.0	3.5*	0%	10
30 minutes or less	0.0	7.3	0%	10
60 minutes or less	7.0	14.6	48%	10
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	10
30 minutes or less	0.0	2.2	0%	10
1 hour or less	0.0	4.4	0%	10
2 hours or less	6.0	8.8	68%	10
4 hours or less	33.0	17.6	187%	10
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	10
1 hour or less	0.0	1.8	0%	10
2 hours or less	0.0	3.6	0%	10
4 hours or less	11.0	7.2	153%	10
8 hours or less	31.0	14.4	215%	10
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	10
2 hours or less	0.0	1.8	0%	10
4 hours or less	4.0	3.6	111%	10
8 hours or less	13.0	7.2	181%	10
16 hours or less	28.0	14.4	194%	10

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Cumbernauld during the period of years shown in column 'D'.

2. The estimated frequencies in column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 22

INTENSITIES OF RAINFALL RECORDED AT TURNHOUSE (EDINBURGH) AIRPORT, MIDLOTHIAN

Number of Days with Specified Amounts of Rain Falling in Specified Times (22 years from 1949 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	1	1	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0	0	0	0	1
1969	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
1967	0	0	1	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
1966	2	3	4	0	1	2	3	0	1	1	1	3	0	0	0	0	3	0	0	0	2	2
1965	0	0	1	0	0	1	1	0	0	1	1	3	0	0	0	0	1	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
1962	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	2	4	0	0	0	2	2
1961	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	2	0	0	0	2	2
1960	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1
1959	0	1	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	2	3	5	0	0	1	1	0	0	1	1	2	0	0	1	1	2	0	0	1	2	2
1957	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	3	0	0	0	1	3
1956	0	2	2	0	0	0	1	0	0	0	0	4	0	0	0	0	3	0	0	0	0	3
1955	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
1954	-	-	-	0	0	0	1	0	0	0	1	2	0	0	0	1	3	0	0	0	2	2
1953	-	-	-	0	1	1	1	0	0	0	1	2	0	0	0	0	1	0	0	0	1	1
1952	-	-	-	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1
1951	-	-	-	0	0	0	1	0	0	0	2	5	0	0	1	2	4	0	0	1	3	3
1950	-	-	-	0	0	0	1	0	0	0	1	3	0	0	0	0	1	0	0	0	1	3
1949	-	-	-	0	0	0	2	0	0	0	1	3	0	0	1	2	4	0	0	2	3	5
Total	4	11	17	0	2	8	15	0	1	3	10	40	0	0	3	11	39	0	0	4	20	37
Number of Years of Record	15	15	15	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22

TABLE 22A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT TURNHOUSE (EDINBURGH) AIRPORT, MIDLOTHIAN

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	2.7	5.5*	49%	15
10 minutes or less	7.3	14.9	49%	15
15 minutes or less	11.3	22.3	51%	15
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	22
15 minutes or less	0.9	3.5*	26%	22
30 minutes or less	3.6	7.3	49%	22
60 minutes or less	6.8	14.6	47%	22
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	22
30 minutes or less	0.5	2.2	23%	22
1 hour or less	1.4	4.4	32%	22
2 hours or less	4.5	8.8	51%	22
4 hours or less	18.2	17.6	103%	22
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	0.0	0.8*	0%	22
1 hour or less	0.0	1.8	0%	22
2 hours or less	1.4	3.6	39%	22
4 hours or less	5.0	7.2	69%	22
8 hours or less	17.7	14.4	123%	22
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	0.0	0.9	0%	22
2 hours or less	0.0	1.8	0%	22
4 hours or less	1.8	3.6	50%	22
8 hours or less	9.1	7.2	126%	22
16 hours or less	16.8	14.4	117%	22

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Turnhouse (Edinburgh) Airport during the period of years shown in Column 'D'.
2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 23

INTENSITIES OF RAINFALL RECORDED AT HADDINGTON, EAST LOTHIAN

Number of Days with Specified Amounts of Rain falling in specified times (7 years from 1964 to 1970)

Year	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
1970	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	1
1969	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1
1968	0	1	2	0	0	1	1	0	0	1	1	3	0	0	0	0	2	0	0	0	0	2
1967	0	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	2
1966	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	3	0	0	0	2	4
1965	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	2	0	0	0	1	2
1964	0	0	2	0	0	0	1	0	0	0	1	2	0	0	0	1	3	0	0	1	2	3
Total	0	2	6	0	1	2	3	0	1	2	4	12	1	1	1	4	14	1	1	2	7	15
Number of Years of Record	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7

TABLE 23A

COMPARISON OF OBSERVED AND ESTIMATED INTENSITIES OF RAINFALL AT HADDINGTON, EAST LOTHIAN

Number of days in 10 years with specified amounts of rain falling in specified times

	A. Observed Frequency (number of days in 10 years)	B. Estimated Frequency (number of days in 10 years)	C. Observed Frequency as Percentage of Estimated Frequency	D. Period of Record used for Calculation of A. (years)
Amount of 5 millimetres (0.2 inches) falling within:				
5 minutes or less	0.0	5.5*	0%	7
10 minutes or less	2.9	14.9	19%	7
15 minutes or less	8.6	22.3	39%	7
Amount of 10 millimetres (0.4 inches) falling within:				
5 minutes or less	0.0	0.3*	0%	7
15 minutes or less	1.4	3.5*	40%	7
30 minutes or less	2.9	7.3	40%	7
60 minutes or less	4.3	14.6	29%	7
Amount of 15 millimetres (0.6 inches) falling within:				
15 minutes or less	0.0	0.9*	0%	7
30 minutes or less	1.4	2.2	64%	7
1 hour or less	2.9	4.4	66%	7
2 hours or less	5.7	8.8	65%	7
4 hours or less	17.1	17.6	97%	7
Amount of 20 millimetres (0.8 inches) falling within:				
30 minutes or less	1.4	0.8*	175%	7
1 hour or less	1.4	1.8	78%	7
2 hours or less	1.4	3.6	39%	7
4 hours or less	5.7	7.2	79%	7
8 hours or less	20.0	14.4	139%	7
Amount of 25 millimetres (1.0 inches) falling within:				
1 hour or less	1.4	0.9	155%	7
2 hours or less	1.4	1.8	78%	7
4 hours or less	2.9	3.6	81%	7
8 hours or less	10.0	7.2	139%	7
16 hours or less	21.4	14.4	149%	7

Notes

1. The observed frequencies in Column 'A' above were calculated from intensities of rainfall recorded at Haddington during the period of years shown in Column 'D'.

2. The estimated frequencies in Column 'B' above were obtained from Bilham's formula:

$$n = \frac{1.25t}{(r + 0.1)^{3.55}}$$

where: n = frequency (number of days in 10 years)
t = duration in hours
r = rainfall in inches

But the following modification due to D J Holland for intensities greater than 1.25 inches per hour was used to estimate the frequencies marked with an asterisk:

$$n = \frac{r \exp. \left(1 - \frac{0.8r}{t}\right)}{(r + 0.1)^{3.55}}$$

TABLE 24

Observed frequency of number of days in 10 years with specified amounts of rain falling in specified times
(calculated from data in Tables 1 to 23)

Station	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
Eskdalemuir	2.7	8.0	17.3	0.3	2.4	6.1	15.8	0.6	0.9	3.6	13.3	71.2	0.3	0.3	2.7	20.9	78.2	0.3	0.6	7.3	37.3	84.8
West Freugh	0.0	3.3	4.7	0.0	0.8	3.3	8.7	0.0	0.0	2.5	7.9	34.6	0.0	0.0	1.7	10.8	27.5	0.0	0.0	1.3	13.7	27.1
Prestwick Airport	0.0	3.3	7.3	0.0	1.3	1.7	6.7	0.0	0.4	1.3	4.2	15.8	0.0	0.4	1.3	5.4	16.7	0.0	0.4	2.1	5.0	14.6
Glasgow Airport	0.7	2.7	6.0	0.0	1.8	2.4	5.8	0.3	0.9	1.8	3.9	25.5	0.6	0.9	1.2	7.3	24.2	0.6	1.2	1.8	10.0	25.1
Sloy Power Stn	1.0	6.0	14.0	0.0	2.0	2.0	27.0	1.0	1.0	4.0	36.0	185.0	1.0	1.0	8.0	78.0	202.0	1.0	3.0	29.0	120.0	202.0
Machrihanish	0.0	1.7	3.3	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	28.3	0.0	0.0	0.0	10.0	23.3	0.0	0.0	0.0	11.7	23.3
Kinlochewe	3.3	3.3	5.0	0.0	0.0	3.3	13.3	0.0	0.0	0.0	18.3	96.7	0.0	0.0	1.7	41.7	90.0	0.0	0.0	16.7	53.3	98.3
Tiree	0.7	4.7	11.3	0.0	0.0	1.2	10.6	0.0	0.0	1.2	7.1	25.3	0.0	0.0	2.3	7.6	27.1	0.0	0.0	3.5	10.6	24.7
Isle of Rhum	1.1	11.1	15.5	0.0	0.0	5.5	44.4	0.0	0.0	4.4	51.1	192.2	0.0	2.2	12.2	76.7	192.2	0.0	1.1	30.0	106.7	181.1
Stornoway	0.0	0.7	2.0	0.0	0.0	0.6	2.3	0.0	0.0	0.0	1.8	10.0	0.0	0.0	0.0	1.8	13.5	0.0	0.0	0.6	2.9	11.8
Benbecula	1.3	2.7	5.3	0.0	1.2	2.3	8.2	0.0	0.0	1.2	4.7	18.2	0.0	0.0	1.2	4.7	18.8	0.0	0.0	1.2	4.1	22.3
Lerwick	0.7	2.7	3.3	0.0	0.0	0.6	2.9	0.0	0.0	0.6	1.8	15.3	0.0	0.6	0.6	2.3	18.2	0.0	0.6	0.6	4.1	18.8
Kirkwall Airport	0.0	1.3	3.3	0.0	0.0	0.8	3.3	0.0	0.0	0.4	1.7	11.7	0.0	0.0	0.4	1.7	12.1	0.0	0.0	0.4	4.6	12.9
Wick	0.7	2.7	6.7	0.0	0.4	1.7	5.2	0.0	0.0	0.0	3.5	9.1	0.0	0.0	0.0	2.6	12.6	0.0	0.0	0.4	1.7	13.0
Mullardoch Dam	0.0	2.5	3.7	0.0	0.0	1.3	16.3	0.0	0.0	1.3	7.5	56.3	0.0	0.0	3.7	18.7	63.7	0.0	0.0	7.5	37.5	75.0
Dalcross Airport	0.0	0.0	3.0	0.0	0.0	1.0	6.0	0.0	0.0	1.0	5.0	11.0	0.0	0.0	2.0	6.0	17.0	0.0	0.0	3.0	7.0	20.0
Kinloss	0.7	5.3	9.3	0.0	1.0	3.0	4.5	0.0	0.5	1.0	3.5	15.0	0.0	0.0	1.0	3.5	12.5	0.0	0.0	1.0	6.0	13.0
Dyce Airport	2.0	9.3	12.7	0.0	1.2	2.8	9.6	0.8	1.6	1.6	6.0	26.0	0.8	0.8	1.2	8.8	30.0	0.0	0.4	2.4	11.6	28.8
Leuchars	2.0	6.0	10.0	0.0	2.1	3.2	7.6	0.3	0.9	1.8	5.6	16.8	0.0	0.6	1.5	6.5	17.9	0.0	0.3	2.3	7.3	17.3
Stronachlachar	2.5	7.5	15.0	0.0	0.0	1.7	17.5	0.0	0.0	0.0	18.3	114.2	0.0	0.0	1.7	40.8	134.2	0.0	0.0	15.8	64.2	149.2
Cumbernauld	0.0	2.0	8.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	6.0	33.0	0.0	0.0	0.0	11.0	31.0	0.0	0.0	4.0	13.0	28.0
Turnhouse Airport	2.7	7.3	11.3	0.0	0.9	3.6	6.8	0.0	0.5	1.4	4.5	18.2	0.0	0.0	1.4	5.0	17.7	0.0	0.0	1.8	9.1	16.8
Haddington	0.0	2.9	8.6	0.0	1.4	2.9	4.3	0.0	1.4	2.9	5.7	17.1	1.4	1.4	1.4	5.7	20.0	1.4	1.4	2.9	10.0	21.4

TABLE 24A

Observed frequencies of number of days in 10 years with specified amounts of rain falling in specified times expressed as percentages of estimated Bilham frequencies
(compiled from data given in Column 'C' of Tables 1A to 23A)

Station	Amount of 5 mm (0.2 inch) falling within			Amount of 10 mm (0.4 inch) falling within				Amount of 15 mm (0.6 inch) falling within					Amount of 20 mm (0.8 inch) falling within					Amount of 25 mm (1.0 inch) falling within				
	5 mins	10 mins	15 mins	5 mins	15 mins	30 mins	1 hr	15 mins	30 mins	1 hr	2 hrs	4 hrs	30 mins	1 hr	2 hrs	4 hrs	8 hrs	1 hr	2 hrs	4 hrs	8 hrs	16 hrs
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Eskdalemuir	49	54	78	100	69	84	108	67	41	82	151	405	37	17	75	290	543	33	33	203	518	589
West Freugh	0	22	21	0	23	45	59	0	0	57	90	197	0	0	47	150	191	0	0	36	190	188
Prestwick Airport	0	22	33	0	37	23	46	0	18	29	48	90	0	22	36	75	116	0	22	58	69	101
Glasgow Airport	13	18	27	0	51	33	40	33	41	41	44	145	75	50	33	101	168	67	67	50	139	174
Sloy Power Station	18	40	63	0	57	27	185	111	45	91	409	1051	125	55	222	1083	1403	111	167	805	1667	1403
Machrihanish	0	11	15	0	0	0	12	0	0	0	0	161	0	0	0	139	162	0	0	0	163	162
Kinlochewe	60	22	22	0	0	45	91	0	0	0	208	549	0	0	47	579	625	0	0	464	740	683
Tiree	13	32	51	0	0	16	73	0	0	27	81	144	0	0	64	106	188	0	0	97	147	172
Isle of Rhum	20	75	70	0	0	75	302	0	0	100	581	1092	0	122	339	1065	1335	0	61	833	1482	1258
Stornoway	0	5	9	0	0	8	16	0	0	0	20	57	0	0	0	25	94	0	0	17	40	82
Benbecula	24	18	24	0	34	32	56	0	0	27	53	103	0	0	33	65	131	0	0	33	57	155
Lerwick	13	18	15	0	0	8	20	0	0	14	20	87	0	33	17	32	126	0	33	17	57	130
Kirkwall Airport	0	9	15	0	0	11	23	0	0	9	19	66	0	0	11	24	84	0	0	11	64	90
Wick	13	18	30	0	11	23	36	0	0	0	40	52	0	0	0	36	87	0	0	11	24	90
Mullardoch Dam	0	17	17	0	0	18	112	0	0	29	85	320	0	0	103	260	442	0	0	208	521	521
Dalcross Airport	0	0	13	0	0	14	41	0	0	23	57	63	0	0	55	83	118	0	0	83	97	139
Kinloss	13	36	42	0	29	41	31	0	23	23	40	85	0	0	28	49	87	0	0	28	83	90
Dyce Airport	36	62	57	0	34	38	66	89	73	36	68	148	100	44	33	122	208	0	22	67	161	200
Leuchars	36	40	45	0	60	44	52	33	41	41	64	95	0	33	42	90	124	0	17	64	101	120
Stronachlachar	45	50	67	0	0	23	120	0	0	0	208	649	0	0	47	567	932	0	0	439	892	1036
Cumbernauld	0	13	36	0	0	0	48	0	0	0	68	187	0	0	0	153	215	0	0	111	181	194
Turnhouse Airport	49	49	51	0	26	49	47	0	23	32	51	103	0	0	39	69	123	0	0	50	126	117
Haddington	0	19	39	0	40	40	29	0	64	66	65	97	175	78	39	79	139	155	78	81	139	149

TABLE 25

MAXIMUM RAINFALL IN INCHES FROM MODIFIED BILHAM FORMULA

Duration (minutes)	Return Period (years)						
	1 day per Annum	1 day per 2 years	1 day per 5 years	1 day per 10 years	1 day per 20 years	1 day per 50 years	1 day per 100 years
2 minutes or less	0.09	0.11	0.14	0.16	0.19	0.22	0.24
4 " " "	0.15	0.18	0.23	0.27	0.31	0.36	0.40
6 " " "	0.18	0.23	0.30	0.35	0.40	0.48	0.54
8 " " "	0.21	0.27	0.35	0.41	0.48	0.58	0.65
10 " " "	0.24	0.30	0.39	0.47	0.55	0.66	0.75
15 " " "	0.28	0.36	0.48	0.58	0.68	0.83	0.96
20 " " "	0.31	0.40	0.54	0.66	0.79	0.97	1.12
25 " " "	0.34	0.43	0.58	0.72	0.87	1.09	1.27
30 " " "	0.36	0.46	0.62	0.77	0.94	1.18	1.39
40 " " "	0.40	0.50	0.68	0.85	1.05	1.34	1.59
50 " " "	0.43	0.54	0.73	0.91	1.13	1.46	1.75
60 " " "	0.46	0.58	0.78	0.96	1.19	1.56	1.88
90 " " "	0.52	0.66	0.88	1.09	1.35	1.78	2.18
120 " " "	0.58	0.72	0.96	1.19	1.47	1.94	2.38

Example: The maximum rainfall in 60 minutes or less one one day in 50 years = 1.56 inches.

FACTORS FOR CONVERTING POINT RAINFALLS INTO AREAL RAINFALLS

Area (acres)	Duration (minutes)						
	2	6	10	15	30	60	120
100	0.94	0.95	0.96	-	-	-	-
150	0.92	0.94	0.95	0.95	0.96	-	-
200	0.91	0.93	0.94	0.94	0.95	0.95	0.96
300	0.89	0.91	0.92	0.93	0.94	0.94	0.95
500	0.86	0.89	0.90	0.91	0.92	0.92	0.93
700	0.83	0.87	0.88	0.89	0.90	0.91	0.92
1000	0.80	0.85	0.86	0.87	0.88	0.89	0.90
1500	0.75	0.81	0.83	0.84	0.86	0.87	0.88
2000	-	-	0.80	0.82	0.83	0.85	0.86
3000	-	-	-	0.78	0.80	0.82	0.83
5000	-	-	-	-	0.74	0.76	0.77
7000	-	-	-	-	-	0.72	0.73

TABLE 26

Observed frequencies of number of days in 10 years with amounts of 25 mm falling within 16 hours, 20 mm falling within 8 hours and 15 mm falling within 4 hours expressed as percentages of estimated Bilham frequencies but ranked according to the annual average rainfall of the stations (compiled from the data given in Table 24A)

Rank	Station	Number of years of available records	Annual average rainfall	Amount of 25 mm (1.0 inch) falling within 16 hours	Amount of 20 mm (0.8 inch) falling within 8 hours	Amount of 15 mm (0.6 inch) falling within 4 hours
		(years)	(mm)	%	%	%
1	Sloy	10	2699	1403	1403	1051
2	Rhum	9	2520	1258	1335	1092
3	Stronachlachar	12	2379	1036	932	649
4	Kinlochewe	6	1970	683	625	549
5	Mullardoch	8	1744	521)	442)	320)
6	Eskdalemuir	33	1582	589)	543)	405)
7	Cumbernauld	10	1147	194	215	187
8	Benbecula	17	1140	155	131	103
9	Lerwick	17	1132	130	126	87
10	Tiree	17	1117	W 172)	188)	144)
11	Machrihanish	6	1097	W 162)	162)	161)
12	Glasgow	33	1035	W 174)	168)	145)
13	West Freugh	24	1015	W 188)	191)	197)
14	Stornoway	17	1002	N 82	94	57
15	Kirkwall	24	1000	N 90	84	66
16	Prestwick	24	938	101	116	90
17	Dyce	25	895	200	208	148
18	Wick	23	761	N 90	87	52
19	Turnhouse	22	685	E 117)	123)	103)
20	Leuchars	34	678	E 120)	124)	95)
21	Dalcross	10	652	E 139)	118)	63)
22	Haddington	7	650	E 149)	139)	97)
23	Kinloss	20	614	90	87	85